# ENGINEERING:

## An Illustrated Weekly Journal.

*EDITED BY WILLIAM H. MAW AND ALEX. RICHARDSON.*

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**Aveling & Porter, Ltd.,**
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and 73, CANNON STREET, LONDON.
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STEAM WAGONS. TRACTORS.
CEMENT-MAKING MACHINERY. 7667

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ON ADMIRALTY AND WAR OFFICE LISTS.
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BOILER FEED PUMPS.
See Advertisement, page 33, last week.
PATENT WATER-TUBE BOILERS,
AUTOMATIC FEED REGULATORS.
And Auxiliary Machinery as supplied to the Admiralty. 3179

**John H. Wilson & Co., Ltd.**
Birkenhead.
See Illustrated Advertisement
Page 131.

**Locomotive Shunting Cranes**

**Steam and Electric Cranes,**
EXCAVATORS, CRANE-NAVVIES, GRABS,
CONCRETE-MIXERS,
SHIPS WINDLASSES, WINCHES, and
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8170
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London Office
15, VICTORIA STREET, S.W. 1.

**Craig & Donald, Ltd., Machine**
TOOL MAKERS, JOHNSTONE, near Glasgow.
For class of Machine Tools see our Illustrated Advertisement every alternate week. 1358

CHANTIERS & ATELIERS
**Augustin-Normand**
67, rue de Perrey—LE HAVRE
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Destroyers, Torpedo Boats, Yachts and Fast Boats, Submarine and Submersible Boats.
NORMAND'S Patent Water-tube Boilers, Coal or Oil Heating. Diesel Oil Engines.

**Electric Lifts**
(UP TO 35 TONS.)
7182
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**Steam Hammers** (with or without guides). Hand-worked or self-acting TOOLS for SHIPBUILDERS & BOILERMAKERS. 7364
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**Hammers, Presses, Furnaces,**
COVENTRY. 610

**Bever, Dorling & Co., Ltd.,**
BRADFORD.
HIGH-CLASS ENGINES FOR ALL PURPOSES.
also WINDING, HAULING, AIR COMPRESSING and PUMPING ENGINES. 1996

**Cranes.—Electric, Steam,**
HYDRAULIC and HAND,
of all types and sizes.
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TUBES LIMITED, BIRMINGHAM. 8179

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SHIPBUILDERS AND ENGINEERS,
GLASGOW.
SPEEDS UP TO 45 MILES AN HOUR.
PADDLE OR SCREW STEAMERS OF
EXCEPTIONAL SHALLOW DRAUGHT.
**Repairs on Pacific Coast**
by YARROWS, LIMITED, Victoria, British Columbia. 7758
SHIPBUILDERS, SHIP REPAIRERS AND ENGINEERS.

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SPECIALISTS IN
**Drillers & Boring Machinery**
for Engine Works and Boiler Shops.
DOLPHIN FOUNDRY, LEEDS. 4547

**Yachts, Launches or Barges**
Built complete with Steam, Oil or Petrol Motors; or Machinery supplied. Od 3551
VOSPER & CO., LTD., BROAD STREET, PORTSMOUTH.

**Cochran** MULTITUBULAR AND CROSS-TUBE TYPES.
**Boilers.**
See page 17, Nov. 7. 7363

**Electric Cranes.**
7189
S. H. HEYWOOD & CO., LTD.,
REDDISH.

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**Drop Forgings**
write
GARTSHERRIE ENGINEERING & FORGE CO.,
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**Separators**
— FOR —
EXHAUST STEAM
TURBINES COM-
PRESSED AIR, &c.
STEAM DRYERS.
METALLIC PACKINGS.
**Princeps & Co.,**
SHEFFIELD. 6686

**Tank Locomotives**
Specification and Workmanship equal to Main Line Locomotives.
R. & W. HAWTHORN, LESLIE & CO., LTD.,
ENGINEERS, NEWCASTLE-ON-TYNE. 7260

**Excavators.**
FROM 50 TO 600 YARDS PER HOUR.
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LEICESTER. 7295

AERIAL ROPEWAYS, CABLEWAYS, CRANES.
**Steel Castings.**
7379
See displayed advertisement every alternate week.
JOHN M. HENDERSON & CO., ABERDEEN.

**"Spencer-Hopwood" Patent**
Sole Makers:
**Boilers.**
W. H. SPENCER & CO., HITCHIN, HERTS.
See page 15, Nov. 7. 7454

**"Aptol" Oils**
MEAN 7184
**Economy.**
**Henry Wells Oil Co.,**
11, Haymarket, LONDON, S.W. 1.

Iron and Steel
**Tubes and Fittings.**
6930
**The Scottish Tube Co., Ltd.,**
HEAD OFFICE: 34, Robertson Street, Glasgow.
See Advertisement page 111.

**Royles Limited,**
ENGINEERS, IRLAM, MANCHESTER.
FEED WATER HEATERS,
CALORIFIERS, EVAPORATORS, } Row's
CONDENSERS, AIR HEATERS, } PATENTS.
Merrill's Patent TWIN STRAINERS for Pump Suctions.
SYPHONIA STEAM TRAPS, REDUCING VALVES
High-class GUNMETAL STEAM FITTINGS.
WATER SOFTENING and FILTERING. 5723

**Tubes and Fittings,**
IRON AND STEEL.
**Stewarts and Lloyd's, Ltd.,**
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BROAD STREET CHAMBERS, BIRMINGHAM;
and LONDON OFFICE—
WINCHESTER HOUSE, OLD BROAD STREET, E.C.
LONDON WAREHOUSE—167, UPR. THAMES ST., E.C.
LIVERPOOL WAREHOUSE—69, PARADISE ST.
MANCHESTER WAREHOUSE—34, DEANSGATE.
CARDIFF WAREHOUSE—132, BUTE ST.
BIRMINGHAM WAREHOUSES—NILE STREET, SHEEPCOTE STREET, and 10, COLESHILL STREET.
See Advertisement page 36. 7368

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ensure rapid production and reduce prime cost by eliminating machining operations. Write for illustrations to AERATORS LTD., Edmonton, London, N. 18.

**"Petrolex" Fire Extincteur**
puts out flaming motor spirit, burning oil, electric arcs and every kind of fire.—BRITISH FIRE APPLIANCES Co., Ltd., 109, Victoria St., London, S.W. 1.

**Gauges**
FROM
**Stock.**
THE
**Newall Engineering Co.**
(Proprietors, Peter Hooker, Ltd.),
LONDON, E. 17. 7234

**Locomotive Traversers**
(ELECTRIC).
7189
S. H. HEYWOOD & CO., LTD.,
REDDISH.

GOLD MEDAL-INVENTIONS EXHIBITION-AWARDED.
**Duckham's Patent Suspended**
WEIGHING MACHINES.—EAST FERRY ROAD ENGINEERING WORKS COMPANY, LTD.
LONDON, E.—Hydraulic Cranes, Grain Elevators, &c.
See Illus. Advt. last week, page 18. 7917

**Rubber** MANUFACTURERS.
**Hose** Suction and Fire.
GUTTA PERCHA & RUBBER, LIMITED,
Toronto - - Canada. 7555

Patent
**See's Hydro-Pneumatic Ash Ejector.**
Great saving of labour. No noise. No dust. No dirt. Ashes discharged 20ft. clear of vessel.—Apply, F. J. TREWENT & PROCTOR, LTD., Naval Architects and Surveyors, 43, Billiter Bldgs., Billiter St., London, E.C. Od 4636

**Diesel Driven Generators.**
400/500 Kw., D.C., 500 or 250 volts, 330 r.p.m. in excellent condition. Low price.
Also several 170 Kw. Bellias & Morcom-Siemens GENERATING SETS, 220 volts, D.C., and Parsons TURBINES, 500 Kw., 230 volts, D.C., complete with Condenser.
MOTORS from 5/100 HP., 220/250 volts.
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West Walls, Newcastle-on-Tyne. 7309

**The Glasgow Railway Engineering Company,**
GOVAN, GLASGOW. LTD.
London Office—12, Victoria Street, S.W.
MANUFACTURERS OF
RAILWAY CARRIAGE, WAGON & TRAMWAY WHEELS & AXLES.
CARRIAGE & WAGON IRONWORKS, also CAST-STEEL AXLE BOXES. 7312

Tel.: "SONDELA." P.O. BOX 859.
**J. E. Parker,**
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CONSULTING ENGINEER, 8038
Pretoria, S.A.
Mining. Mechanical.
Industrial.

**Yarrow Patent**
**Water-Tube Boilers.**
7705
MESSRS. YARROW & CO., UNDERTAKE the PRESSING and MACHINING of the various parts of Yarrow Boilers, such as the Steam Drums, Water Pockets, and Superheaters for British and Foreign Firms not having the necessary facilities.
YARROW & CO., LTD., SCOTSTOUN, GLASGOW.

**John Bellamy Limited,**
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**Boilers, Tanks & Mooring Buoys**
STILLS, PETROL TANKS, AIR RECEIVERS, STEEL CHIMNEYS, RIVETTED STEAM and VENTILATING PIPES, HOPPERS, SPECIAL WORK, REPAIRS OF ALL KINDS.
RAILWAY AND TRAMWAY ROLLING STOCK.
**Hurst, Nelson & Co., Ltd.**
THE GLASGOW ROLLING STOCK AND PLANT WORKS,
MOTHERWELL. Od 3389

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LIMITED.
See Advertisement page 96, Nov. 7. 3409

**Gas and Oil Engine Repairs.**
—E. J. DAVIS & CO., Great Eastern Road, Stratford, E. 15.
Tel.: 736 and 737 Stratford.
Gram.: Rapidising, London. 1794

THE GLASGOW ROLLING STOCK AND PLANT WORKS
**Hurst, Nelson & Co., Ltd.,**
Builders of RAILWAY CARRIAGES, WAGONS ELECTRIC CARS and EVERY OTHER DESCRIPTION OF RAILWAY and TRAMWAY ROLLING STOCK.
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**Steel Castings.**
THOMAS SUMMERSON & SONS, LTD.,
DARLINGTON. 790

**Electric Transporters.**
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MANUFACTURERS OF
RAILWAY CARRIAGES AND WAGONS
OF EVERY DESCRIPTION.
RAILWAY IRONWORK, BRIDGES, ROOFING, &c.
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**For Sale.—**
One 15 in. stroke SLOTTING MACHINE by Nobel & Lund of Newcastle, balanced ram, quick return, 3 ft. circular table, self-acting in all motions, and in perfect order.
DICK-CLELAND, HARPER & Co.,
40, Jamaica Street, Glasgow.
Yards and Stores: 119, Milton Street, Glasgow, and Shieldmuir, Wishaw.
Telegraphic Address: "Pulley, Glasgow."

**Centrifugals.**
**Pott, Cassels & Williamson,**
MOTHERWELL, SCOTLAND. 7940
See half-page Advertisement page 98, Oct. 31.

**B. & S. Massey, Ltd.,**
MANCHESTER.
**Steam Hammers,**
**Power Hammers,**
**Drop Stamps,**
QUICK DELIVERY. **Band Saws.** LARGE STOCK. 7256

## The Manchester Steam Users' ASSOCIATION.

For the prevention of Steam Boiler Explosions and for the Attainment of Economy in the Application of Steam. 9, Mount Street, Manchester.
Chief Engineer: C. E. STROMEYER, M.I.C.E.
Founded 1854 by Sir William Fairbairn.
Certificates of Safety issued under the Factory and Workshops Act, 1901. Compensation for Damages and Liabilities paid in case of Explosions. Engines and Boilers inspected during construction. 7479

## The National Foremen's ASSOCIATION OF THE ENGINEERING AND ALLIED TRADES.

(Registered under the Trade Union Act.)

An Association specially formed to look after the interests of Foremen on their Supervisory Capacity. A 630

All communications to— H. W. RHID, General Secretary. Head Offices— 81, High Holborn London, W.C. 1.

## Inst. C.E. Exams.—Over 300

successes by Correspondence Coaching. Several prizes. Sec. "O" now prepared. (Designs, Specifications and Quantities). A few vacancies open.—Address, 7434 Offices of Engineering.

## Correspondence Courses for

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## Inst. C.E., I. Mech. E., B.Sc.,

and all Engineering Examinations.—Mr. G. P. KNOWLES, B.Sc., Assoc. M. Inst. C.E., F.S.I., M.R.San.I., PREPARES CANDIDATES personally or by correspondence. Hundreds of successes. Courses may commence at any time.—39, Victoria St., Westminster, S.W. 7882

## A.M.I.C.E. and A.M.I.M.E.

Tuition. Also Postal Courses in Mechanical Engineering, Aircraft Design and Mathematics.—PENNINGTONS, 264, Oxford Road, Manchester.


## TENDERS.

METROPOLITAN BOROUGH OF HAMMERSMITH.

ELECTRICITY DEPARTMENT.

The Council invite

## Tenders for the following:

(a) STATIC TRANSFORMERS.
(b) E.H.T. and L.T. CABLE.
(c) H.T. OIL BREAK SWITCHES.
(d) Black and Galvanised CORRUGATED IRON SHEETS.
(e) STEAM PIPING.

Full Particulars and Forms of Tender may be obtained from Mr. G. G. BELL, Borough Electrical Engineer, Electricity Department, 85, Fulham Palace Road, W.6.

Sealed Tenders, endorsed "Tender for Plant" must be delivered to the undersigned not later than Four p.m. on Thursday, the 20th November, 1919.

The Council does not bind itself to accept the lowest or any Tender.

LESLIE GORDON, Town Clerk.
Town Hall, Hammersmith, W.6.
29th October, 1919. B 366

ROCHFORD UNION.

HOT WATER HEATERS FOR SALE.

## The Guardians have for

DISPOSAL, in good condition, one large sectional Low Pressure Hot Water Heater by Messrs F. A. Norris & Co., 11 & 12, St. Andrew's Hill, E.C.

Also two smaller circular Low Pressure Hot Water Heaters, and invite offers for the purchase of the same.

The Water Heaters can be seen on application to the Master at the Poor Law Institution, Rochford (G.E.R. Station).

The person whose offer is accepted will be expected to remove the Water Heaters from their present position at his own expense, and make good any damage done to the premises.

Offers, under cover, marked "Hot Water Heaters" should reach me not later than Monday, the 1st December, proximo,

By Order,
W. HARDING ROBERTS, Clerk.

40, Clarence Street, Southend-on-Sea.
7th November, 1919. B 351

G. R.

MINISTRY OF MUNITIONS.

BY DIRECTION OF THE DISPOSAL BOARD
(Plant and Machinery Section).

## For Sale by Public Tender:—

Six ¾ in. FOUR-SPINDLE GRIDLEY AUTOMATICS.
20 No. 2 VICTORIA CAPSTAN LATHES, by Selson Engineering Co.
Four ¾ in. No. 53 NATIONAL ACME AUTOMATICS.

Lying at Messrs. Kirby Banks Screw Co., Ltd., Beeston, Leeds.

Tenders for the above must be received not later than Ten a.m., November 22nd.

Tender Forms and Permits to view, and all further information can be obtained on application to the Controller D.B. 1 (E), Charing Cross Embankment Buildings, W.C. 2.

Note.—For particulars of other Government property for sale, see *Surplus*, price 3d., at all bookstalls; or by quarterly subscription of 2s. post free, payable in advance to the Director of Publicity, Ministry of Munitions, Whitehall Place, London, S.W. 1. B 335

LONDON COUNTY COUNCIL.

## Tenders are Invited for the

SUPPLY to the London County Council for the London Fire Brigade Two MOTOR CHASSIS for Turntable Long Ladders; chassis to be capable of carrying a load of 4½ tons. A copy of the outline specification and further particulars can be obtained by written application to the Chief Officer of the London Fire Brigade, Headquarters, Southwark Bridge Road, S.E. 1.

JAMES BIRD,
Clerk of the London County Council.
B536

## Tenders are Invited for

CEMENT PLANT MACHINERY, CONSTRUCTIONAL STEEL-WORK, ELECTRIC POWER PLANT, &c.

Contract.

No. 1. Rotary Kiln complete.
2. Stone Breakers. Ball and Tube Mills.
3. Constructional Steel-work, Buildings, Roofs, Tanks.
4. Transporters, Elevators, Conveyors.
5. Electric Power Installation, Motors.
6. Sea-water Evaporating and Condensing Plant.
7. Aerial Ropeways, Tramways, Trams.
8. Brick Chimney.
9. Weighing Machines.
10. Ferro-concrete Silos.
11. Rails, Points and Crossings, Sleepers.
12. Air Compressors.

Plans may be inspected and particulars obtained from REES & CO., Consulting Engineers, 16, Clifton Gardens, London, W. 9. B 584

G. R.

## The Admiralty have for Sale

the SALVAGE VESSEL "MELITA," lying at H.M. Dockyard, Devonport.

Particulars are as follows:—

| | | |
|---|---|---|
| Length, B.P. | ... ... | 165 ft. |
| Breadth Ex. | ... ... | 31 ft. |
| Tonnage (approx.) | ... | { Registered 269. Gross 442. |
| Displacement | ... ... | 850 tons (approx.). |
| Boilers | ... ... ... | 2 Cylindrical Working Pressure, 145 lbs. per sq. in. |
| Engines | ... ... ... | Horizontal Triple Expansion I.H.P. 1120 (forced draught) Surface Condensing. |

The vessel is fully equipped with suitable plant for undertaking salvage operations.

Tender forms with permission to inspect may be obtained from the DIRECTOR OF CONTRACTS, Branch 8, Room 80, West Block, Admiralty, London, S.W. 1.

Tenders will be received up to Twelve o'clock noon on Monday, 22nd December, 1919. B 555

CONTRACTS, &c.

GREAT SOUTHERN & WESTERN RAILWAY (IRELAND)

CONTRACTS, 1920.

The Directors of the Great Southern and Western Railway Company are prepared to receive

## Tenders for the Supply of

the undermentioned STORES for Six Months commencing 1st January, 1920:—

| | No. of Form. | | No. of Form. |
|---|---|---|---|
| Baskets ... ... | 10 | India Rubber Goods | 9A |
| Bolts, Nuts and Rivets | 15 | Implements, Sundry | 21 |
| Brooms and Brushes | 13 | Iron Tubes and Fittings... ... ... | 29 |
| Brass Fittings for Carriages ... ... | 18 | Iron and Steel Wire | 30A |
| Do. do. for Lamps | 18A | Leather ... ... | 12 |
| Do. do. for Water | 28A | Linen ... ... ... | 6 |
| Do. do. for Gas ... | 26B | Locks and Keys ... | 19 |
| Bunting ... ... | 7B | Mats, Fibre ... ... | 10 |
| Canvas and Sacks ... | 6 | Morocco ... ... | 7B |
| Carriage Laces ... | 7A | Nails ... ... ... | 31 |
| Castings, Mall. Iron | 11 | Oak Keys ... ... | 35A |
| Cement ... ... | 34 | Oak Trenails ... ... | 35B |
| Cloth Carr. and Uniforms ... ... | 7C | Plumbago ... ... | 41 |
| Clothing, Oil... ... | 9B | Railway Fastenings (Iron) ... ... | 16 |
| Do. I.R. proofed | 9B | Railway Fastenings (Steel) ... ... | 16A |
| Coach Screws and Washers ... ... | 15 | Rain Water Pipes and Gutters ... ... | 25 |
| Colours ... ... | 2 | Ropes, Twine, and Flax ... ... ... | 4 |
| Corks ... ... ... | 39 | Sewer Pipes, Plaster, etc. ... ... ... | 32 |
| Cotton Waste ... | 5A | Shovels, Spades, etc. | 21A |
| Crucibles ... ... | 41 | Soft Goods ... ... | 8 |
| Drysalteries ... ... | 3 | Sponge Cloths ... | 5 |
| Emery and Glass Cloth, etc. ... ... | 38 | Signal Wire Pulleys | 11 |
| Files and Tool Steel | 20 | Screws and Split Pins | 14 |
| Fire Bricks and Clay | 33 | Tin Plates ... ... | 23 |
| Foundry Requisites | 42 | Varnishes ... ... | 1 |
| Galv. Sheets, Buckets, etc. ... ... ... | 23 | Waste ... ... ... | 5A |
| Grates, Stoves and Fenders ... ... | 24 | Waterproof Clothing | 9B |
| Grindstones ... ... | 36 | Wicks ... ... ... | 5 |
| Glass, Sheet and Plate | 27A | Wire, Fence and Signal ... ... | 30A |
| Glass and China Sundries ... ... | 27B | Wirework ... ... | 30B |
| Hardware (Sundry)... | 17 | | |
| Incandescent Fittings for Gas ... ... | 26C | | |

Forms of Tender can be obtained on *PAYMENT* of 6d. each from the STORES SUPERINTENDENT, GENERAL STORES DEPARTMENT, G.S. & W.R., INCHICORE, DUBLIN. Applications for forms by Post must be accompanied by Postal Order. Stamps cannot be accepted. All enquiries for information should be also directed to the Stores Superintendent.

Patterns may be inspected at the General Stores Department on and after the 14th inst., between the hours of Ten a.m. and Four p.m. (except on Saturdays).

Tenders must be enclosed in the special envelope supplied for the purpose with each Schedule, and must be posted so as to be with the undersigned before 10 a.m., on Wednesday, 26th November, 1919

The Directors will not consider any Tender unless it is furnished on the Company's Form, and do not bind themselves to accept the lowest or any Tender.

By Order,
(Signed) ROBERT CRAWFORD, Secretary.
Kingsbridge Terminus, Dublin,
November, 1919. B 499

## Sale by Private Tender.

COMPLETE ALTERNATING CURRENT GENERATING PLANT, CONSISTING OF:—

One 525 B.HP and Two 200 HP. Carels three-cylinder Diesel Oil Engines, with Reavell Compressors, direct coupled to—
Two 218 Kw. and One 325 Kw. Dick-Kerr two-phase, 2000 volt, 50 period Alternators, with Direct-coupled Exciters.
Complete Auxiliary Gear, consisting of Reavell four-stage Compressor, driven by direct coupled 2000 volt, two-phase, 100 HP. Induction Motor, Marble Switchboard with Mechanical Remote Control for Three Generator and Two Feeder Panels, with the usual measuring and synchronising gear. Motor-driven, water circulating and fuel Oil Pumps; Heenan and Froude Water Cooling Plant for 7000 gallons per hour, Cooling Water and Fuel Oil Tank, Fuel Oil Storage Tanks of 90 tons capacity, and a quantity of New and Second-hand Spare Parts.
Also One 30 ton Engine Room Crane, 47 ft. span, with Hand Traverse and Electric Hoist; and One 15 ton Ditto, Hand Traverse and Hoist, 37 ft. 6 in. span.

The whole is in good running order and adjusted to run on either tar or crude oil.

The Plant may be inspected by prospective purchasers by appointment.

Offers will be considered for whole or part of above Plant. B 606

THE DAIMLER COMPANY, Ltd.,
Daimler Works,
Coventry.

G. R.

MINISTRY OF MUNITIONS.

BY DIRECTION OF THE DISPOSALS BOARD.
(Plant and Machinery Section.)

FOR SALE BY PUBLIC TENDER.
CHEMICAL AND ENGINEER'S PLANT.
DONKEY COOLING PLANT.

## Tenders are invited for the

following:—

31 Donkey Cooler channel staunchions, 22 ft. 8in. long.
210 Donkey Cooler Trays, nearly new.
30 Donkey Cooler Trays, not used.
25 Donkey Cooler Trays, partly prepared.
200 End Plates for same.

KESTNER MATERIAL.

Six Large Type Separators with 3 in. pipes and bends.
16 Small Type Separators with pipes and bends.
Two Sets Triple Effect Condensers with brackets.
Three Sets Double Effect Condensers.
Four Sets 9 in. Vapour Collecting Mains with 5 in. branches.
Four Sets 12 in. Ascension Pipes. 4 ft. 9 in. Pipes with 12 in. by 5 in. branches.
24 1½ in. Safety Valves. 24 ft. 5 in. Sluice Valves.
24 5 in. Pipes, 2 ft. 7 in. long.
Ref. G.421. N.K. No 13,840 to 51.
Tenders close December 15th, 1919.
Above lying at Messrs. Brunner Mond & Co., Ltd., Sandbach Works, Northwich.
Permits to view and Tender forms can be obtained on application to the CONTROLLER, D.B.1.(E), Charing Cross Embankment Building, London, W.C. 2.

Note.—For particulars of other Government Property for sale, see "SURPLUS," price 3d. at all Bookstalls; or by quarterly subscription of 2s., post free, payable in advance to the Director of Publicity, Ministry of Munitions, Whitehall Place, London, S.W. 1. B 625

G. R.

MINISTRY OF MUNITIONS.

BY DIRECTION OF THE DISPOSAL BOARD.
(Plant and Machinery Section).

FOR SALE BY PUBLIC TENDER

VALUABLE MACHINE TOOLS, ETC.,
Lying at Clyno Engineering Co., Limited, Pelham Street, Wolverhampton.

## Tenders are Invited for the

following:—

Three Lincoln Milling Machines.
One No. 5 Fellows Gear Shaper.
Two Taft Pierce Universal Grinders, 10in. by 30in.
Four Straight bed S.S. and S.C. Lathes, 9 in. to 13 in. centres.
Two No. 9 Herbert Combination Turret Lathes.
Five 1 in. Herbert Capstan.
One Van Norman Universal Miller.
One Burton Griffiths Plain Miller by Geoley and Bdlund.
Two 8 in. by 5 ft. straight bed S.S. and S.C. Lathes.
Two Milwaukie Vertical Millers, also 1½ B.
Three Landis Plain Grinders, 12 in. by 36 in.
One Internal Cylinder Grinder by Aikins, Peterborough.
One Archdale Thread Miller, 9 in. centre.
One No. 1 Slot Driller by Richards & Co.
Four Warner & Swasey No. 4 Universal Turret Screw Machines, capacity 1¼ in. Bar.
One 3 ft. 9 in. Elevating Radial Drill by Asquith.
One 9½ in. centre by 5 ft. Relieving Lathe by Smith & Coventry.
One Buckton 60 ton Vertical Single Lever Testing Machine.
Two No. 12½ Garvin Plain Milling Machines.
Three "Porter Cable" Lathes, 7 in. centres by 2 ft. 6 in. bed.
Two 3 ft. 9 in. Elevating Asquith Radial Drills.
Permits to view and all further information, can be obtained from the CONTROLLER, D.B.1.e., Charing Cross Embankment Buildings, London, W.C. 2.
Tenders to be lodged by 10 a.m., December 5th.

Note:—For particulars of other Government Property for Sale, see *Surplus*, price 3d., at all Bookstalls; or by quarterly subscription of 2s., post free, payable in advance, to the Director of Publicity, Ministry of Munitions, Whitehall Place, London, S.W. 1. B 576

MINISTRY OF PUBLIC WORKS, EGYPT.

ABOUKIR PUMPING INSTALLATION.

The Ministry of Public Works, Egypt, invite

## Tenders for the Supply,

DELIVERY, ERECTION and FIXING of the MACHINERY and APPLIANCES necessary for the Complete Equipment of a Pumping Installation at Aboukir in the Province of Behaira.

Tenders will be received by the Director General, Mechanical Department, Ministry of Public Works, Cairo, not later than noon on the 31st December, 1919, and will remain open for three calender months.

Copies of the conditions of Tender, form of Tender and specification may be had on application to Sir A. L. WEBB, K.C.M.G., Queen Anne's Chambers, Broadway, Westminster, S.W. 1. Price 10s. B 653

COUNTY BOROUGH OF ST. HELENS.

The ST. HELENS CORPORATION ELECTRICITY COMMITTEE offers

## For Sale the following Plant:—

One Willans-Dick. Kerr 500 kw. Set, shunt wound 460/500 volts, compound 500/550 volts.
One Willans-Mather & Platt 200 kw. Set, shunt wound 500 volts.
Both suitable for working with a boiler pressure of 180 lbs. per sq.-inch.
Two Wheeler Surface Condensers, 20,000 lbs. steam each.

The plant is in working condition and can be seen by appointment.

Full particulars can be obtained from the undersigned.

Tenders for above should be sent in by 8th December, 1919.

The highest or any Tender not necessarily accepted.

B. T. HAWKINS,
Borough Electrical Engineer,
Electric Power Station,
Carlton Street,
St. Helens. B 683

METROPOLITAN WATER BOARD.

TENDER FOR LAYING, REMOVING AND ALTERING MAINS AT EAST HILL, WANDSWORTH.

The Metropolitan Water Board invite

## Tenders for Laying, Removing and Altering

the Board's MAINS in East Hill in the Borough of Wandsworth, in relation to the Construction of Tramways by the London County Council.

Tenders must be made on the official forms, which may be obtained at the Offices of the Board, Chief Engineer's Department, South Place, Finsbury Pavement, E.C. 2, on and after Saturday, 15th November, 1919, by personal application or on receipt of a stamped addressed brief envelope.

Tenders enclosed in sealed envelopes addressed to "The Clerk of the Board, Metropolitan Water Board, South Place, Finsbury Pavement, E.C. 2," and endorsed "Tenders for Alterations to Mains, East Hill," must be delivered at the Offices of the Board not later than 11 a.m. on Monday, 24th November, 1919.

The Board do not bind themselves to accept the lowest or any tender.

A. B. PILLING,
Clerk of the Board.
South Place, Finsbury Pavement, E.C. 2.
12th November, 1919. B 670

G. R.

MINISTRY OF MUNITIONS.

BY DIRECTION OF THE DISPOSAL BOARD
(Plant and Machinery Section).

## For Sale by Public Tender.

10 ELECTRIC TRAVELLING CRANES, 7 tons. Makers, T. Smith & Sons (Rodley), Ltd., Motors by J. P. Hall & Co. Radius 14 to 20 ft. Lifting capacity 7 tons at 20 ft. radius. 31ft 30 ft. steel lattice. Gauge 4 ft. 8½ in. adaptable to 7 ft. travelling wheels 24 in. dia., single flange. Axles 5½ in. dia. Speeds travelling 300 r.p.m. Hoisting fast and slow gears, 100 and 70 r.p.m. Motor 53 B.HP. series wound, enclosed 500 volts D.C., 650 r.p.m. British Westinghouse Solenoid Break, 115 amps. Reversible Controller, automatic C.B. and other Accessories including a number of Spares. Approximate total weight 30 tons. Reg. G. 1541.
Tenders closing November 26th.
Lying at Admiralty Works, Southwick, near Brighton. (Nearest station Southwick.)

LARGE STORAGE TANKS.

One Tank 116 ft. dia., capacity 8000 tons.
One Tank 82·6 ft. dia., capacity 4000 tons. Ref. G.1421.
Complete with Pipe Lines, &c. (separate prices to be given).
Lying at Albert Edward Dock, Newcastle-on-Tyne.
One Tank 80 ft. dia. by 30 ft. deep of Siemens Martin Steel equal to Lloyds tests. Capacity 3760 tons. Pipe Lines &c. (separate offer to be given). Ref. G. 1331.
Tenders closing November 28th.
C.-I. Pipes, 5, 6, 8, 10, 12, 15 in. dia. Sluice Valves. Expansion Joints. Reducing Pipes, Bends and other Accessories.
Lying at Hendon Road Reservation—adjacent to Alexandra Dock, Hull.
Plans of Tanks can be seen at this office.

LOCOMOTIVES.

Two Standard gauge Locos., Kimberley and Hercules, by Manning Wardle & Co., 6 ft. saddle, tank 120 lb. per sq. in., 12 in. by 17 in. stroke, wheel base 10 ft. 7 in. Weight 17½ ton approx. empty. Ref. 1127.
Closing November 26th.
Lying at Royal Arsenal, Woolwich.
Full particulars and tender forms can be had on application to the CONTROLLER, D.B.1.(E), Charing Cross Embankment Buildings, London, W.C. 2.

Note.—For particulars of other Government Property for sale, see *Surplus*, price 3d. at all bookstalls, or by quarterly subscriptions of 2s. post free, payable in advance to the Director of Publicity, Ministry of Munitions, Whitehall Place, London, S.W. 1. B 576

## THE BOULTON AND WATT RELICS.

By Engineer-Commander Edgar C. Smith, O.B.E., R.N.

When the firm of James Watt and Co.—the successors to Boulton and Watt—about twenty-five years ago closed the doors of the famous Soho Foundry a very large number of drawings, account books, sketch books, letters, &c., the accumulation of a hundred years, was purchased by Mr. George Tangye, the youngest of the brothers who made the Cornwall Works hardly less well known than was the Soho Foundry. Mr. Tangye, since 1876, has been the tenant of Heathfield Hall, which Watt built in 1790 and it was through his kindness visitors to the recent Watt Centenary celebration at Birmingham were able to inspect Watt's garret workshop. For many years the collection of drawings and papers from Soho was in the care of Mr. R. H. Kirton, of the Cornwall Works, and it is interesting to note that the group of visitors photographed on the lawn of Heathfield House included Mr. Tangye and Mr. Kirton, both of whom have passed their 84th birthdays. Previous to their dispersal, the drawings and papers referred to had been preserved in the Watt room at Soho Foundry, where they had been gathered together by the late Mr. W. H. Darlington, who for about 25 years was general manager to James Watt and Co. Mr. Darlington died in August, 1909, at the age of 66. In 1911 Mr. Tangye presented the whole of the collection to the City of Birmingham, and in 1915 a room was set apart for its reception in the Public Library, Ratcliff Square. It is now known as the Boulton and Watt collection. Owing to the war and the depletion of the Staff of the Library, complete indexing and cataloguing has not yet been possible, and much remains to be done in this direction. Relating as it does not only to Watt but also to his contemporaries Boulton, Murdock, Southern and others, the collection is nothing less than a national treasure. It is safe to say that no history of the steam engine or of mechanical engineering written in the future can be complete without adequate research being made into these records. Of the Soho Manufactory erected by Boulton in 1764 nothing now, we understand, remains. It was here Watt experimented with "Beelzebub," it was here "Old Bess" was erected and it was here the Lap engine, now in South Kensington, worked for 60 years. It was here, too, most of Watt's own work was done, but all the later history of the firm is bound up with the Foundry. The "Manufactory" and the "Foundry" erected in 1795–96 have a place apart in the development of engineering manufacture, and in one of his lectures Professor Burstall referred to this, and remarked that the work of Boulton and Watt in starting a system of co-ordinated manufacture was probably as important as the power development which they inaugurated.

Though the Boulton and Watt collection is always open for inspection, the room in which it is housed is rather small, and accordingly it was arranged that during the Centenary meetings an exhibition should be held in a part of the Birmingham Art Gallery. A sub-committee, with Mr. J. C. James Carrington, M.I.Mech.E., as chairman, was appointed to carry this out and the exhibition, opened on September 16, remained on view for about four weeks. It was entirely successful, and the excellent catalogues issued will be a permanent record of the industry of the committee and the value of the exhibition. Free use was made of the collection in the Library, which alone contains some 10,000 drawings, and the committee were able to obtain the loan of books, photographs, pictures, medals and other objects from various collections, including those in the possession of Miss Gertrude Boulton, a descendant of Matthew Boulton, and of Major J. M. Gibson Watt, the great grandson of Watt's daughter, Margaret. Among the personal articles thus shown were Watt's pocket telescope, his box of drawing instruments, his snuff box and a set of cameos executed by him with his sculpturing machine. Many coins and medals struck at Soho were exhibited, but among these we did not see the medal which Boulton struck after the battle of Trafalgar, and of which he presented copies to every officer and man engaged in the action. In various cases were to be seen letters from Smeaton, Robison, Telford, Black and Arkwright, copies of Watt's letters patent, books of instructions for erecting the engines, calculation books, copies of agreements, the Murdock locomotion model lent by Mr. Tangye, Watt's dinner basket and also the muskets kept in readiness for arming the workmen. The absence from the Exhibition of the famous Newcomen model at Glasgow was unavoidable. The main interest of the exhibition, however, lay in the excellent selection of drawings shown in some twenty or thirty panels around the walls. These were chosen to show the development of Watt's inventions, and many of the drawings were his own handiwork. Among the engines illustrated were those supplied to the Birmingham Canal Company (1776), the Shadwell and Chelsea Waterworks (1777), Whitbread's Brewery (1785), Strutt and Sons (1792), Hebburn Colliery (1798), and the engines and boilers for the first English steamboat, the Eagle. Other drawings related to the Beaver, the first steamboat to cross the Pacific, the London

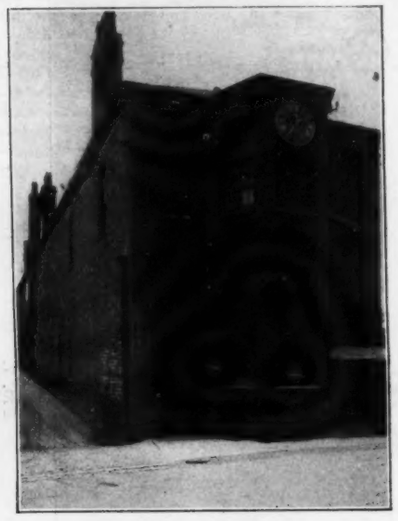


Fig. 1. Original Offices of Boulton and Watt with Clock Tower Gateway.

Fig. 2. Cottages in Foundry Row; Murdock's House on Left.

Fig. 3. Cast Iron Bridge Adjoining the Foundry.

# THE BOULTON AND WATT WORKS AT SOHO, BIRMINGHAM.

Fig. 4. The Coining Mint.

Fig. 5. Vaults under the Foundry.

Fig 6. The Erecting Shop.

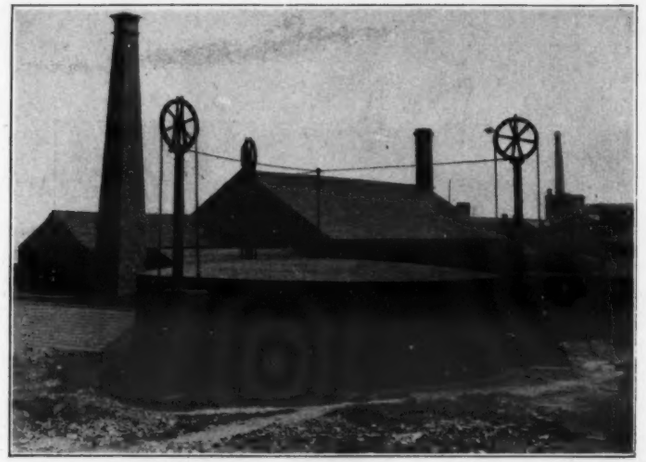


Fig. 7. Murdock's Original Gasometer.

and Margate steam packet Albion, and the engines of H.M.S. Trident (1844) and H.M.S. Centaur (1845), which were among the last vessels in the Navy to be fitted with paddle wheels. It was while the Centaur was building that took place the tug-of-war trials between the Rattler with a screw and the Alecto with paddle wheels, which led to the introduction of screw propulsion. A particularly interesting panel illustrated the evolution of the boiler from the days of the hay stack and waggon boilers to the time when marine boilers had a labyrinthic system of flues. Mention should also be made of the drawings of the engines built by James Watt and Co. for driving the screw of the Great Eastern, which it will be remembered, was provided with both screw and paddles.

For many years marine engine building was one of the most important branches of the work at Soho Foundry, and it remained so till its abandonment about 1878. The original sketch of the engine supplied to Fulton for the Clermont has recently been reproduced in these columns; while in the Boulton and Watt collection can be seen the drawing of the first set of engines ordered in 1815 for naval service. These engines, designed for H.M.S. Congo, were, however, never fitted in the ship, being sent to Devonport Yard for pumping purposes. By 1824 the firm had built no fewer than 76 marine engines, and by 1854 this had been increased to 319. Among these were the engines for H.M.S. James Watt, a line of battleship of 4,950 tons displacement. The James Watt had horizontal simple engines, with four cylinders 52-in. diameter and 3-ft. stroke, and on trial these gave 1,543 i.h.p. at 51 r.p.m., the steam pressure being 16 lb. per square inch. The speed of the ship was 9·361 knots. Most of the early naval steamers, such as the Monkey (1821), Comet (1822), Meteor (1824), Albion, Asp and Avon (1825), were engined by Boulton & Watt when Murdock was manager.

For many years the foreman of the engine factory was William Brunton (1777–1851), who, after leaving Soho in 1818, established himself in Birmingham, and in 1824 engined the Sir Francis Drake, said to be the first steam vessel to take a man-of-war in tow. During the Centenary celebrations among the engineers upon whom the University conferred the honorary degree of LL.D., was the Engineer-in-Chief of the Fleet, Engineer Vice-Admiral Sir George Goodwin, and it is not generally known that the first to hold a position in any way corresponding with his was Peter Ewart, who had assisted James Watt, Jun., to erect the Soho Foundry. Ewart was born at Troquaire Manse, Dumfries, in 1767, being a relation of Watts' life-long friend, John Robison. Through a letter of Robison to Watt, Ewart became an apprentice to Rennie at East Lothian, and afterwards for four years (1784–88) worked under Rennie installing the millwork in Boulton and Watt's ill-fated Albion Mills, which stood at the south-east corner of Blackfriars Bridge. From London he was sent to erect a water wheel at Soho Manufactory, and was thus led to enter the employ of Boulton and Watt, and at the age of 23 was entrusted with the erection of one of their engines. Though he had severed his connection with the firm before 1795, he was called in by James Watt, Jun., to assist in building the Soho Foundry, and after that for about forty years engaged in manufacturing in the Manchester district. Up to 1835 there had been no Chief Engineer of the Navy, and apparently, owing to a letter from the Admiralty to James Watt, Jun., Ewart was invited to occupy this position. He thus became Chief Engineer of the Navy and Inspector of Machinery in 1835 at the age of 68, having his headquarters at Woolwich Dockyard. He ultimately met his death at Woolwich in September, 1842, owing to a blow from a chain which broke during the hoisting of a heavy boiler. In his presidential address to the Institute of Civil Engineers in 1843, Mr. Walker said of Ewart: "His knowledge of machines and particularly of the principles of the steam engine was very intimate. His admiration for Watt and his practice at Soho inclined him to view with some degree of scepticism any innovation in the engine which he considered to have been almost perfected by his great master; and for the public situation which he held this prejudice was probably useful, for the war steamers on active service are not those in which new schemes should first be tried." Ewart's period of office covered the inauguration of a separate Steam Department at Somerset House in 1837, and also the first introduction, through the efforts of Pettit Smith, Brunel, Ericsson and Wimshurst, of the screw propeller into the Navy. What part Ewart took in the great controversy over the question of screw propulsion is not clear. Ewart was for many years a vice-president of the Literary and Philosophical Society of Manchester, in whose proceedings is to be found an elaborate paper by him "On the Measure of Moving Force," and also an obituary notice of him by William Henry, the chemist.

The revival of interest in the work of Watt will, it is hoped, lead not only to the erection of a memorial building to Watt, Boulton and Murdock, but also to the publication of a history of the Soho Foundry. It is also hoped that information may be collected regarding the Watt engines now in existence. Some of the early engines, it is feared, have during the war been broken up as scrap, and with the increased cost of coal it is probable others will be put out of commission. The preservation of some of them at least, appears to be desirable. Beyond those now in South Kensington Museum and the Whitbread engine at Sydney, it is probable there remains no other sun and planet engine. The tracing of the Watt engines still at work should not prove a difficult matter, for in the Boulton and Watt collection there is a detail list of engines made at Soho, and Mr. Hazelton has classified and indexed a large number of the drawings. It was by means of these the identity of an old engine still at work in London was recently established. In a letter to Boulton dated Birmingham, November 5, 1785, Watt wrote: "I had no London news of any importance or would have wrote to you, nothing indeed but what may be safely reserved till we meet. The engines we have

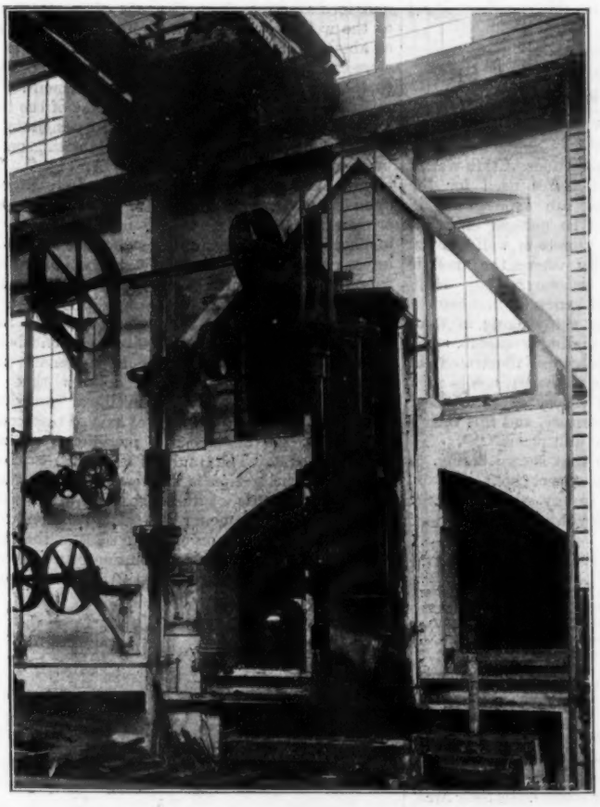


Fig. 8. Wall Drilling Machine.

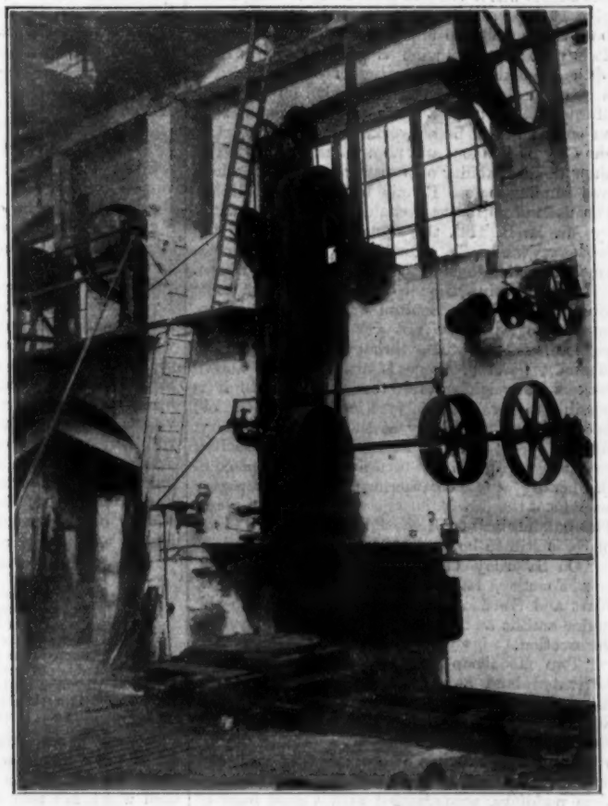


Fig. 9. Slotting Machine.

erected are all doing very well and Felix Calvert has bespoken one which he is to cause to outdo Whitbreads in magnificence." Through enquiries addressed to Messrs. Whitbread it was found that Calvert's brewery was that now known as the City of London Brewery, which stands in Upper Thames Street just to the east of Cannon Street Station. The engine had so long ago as 1884 a reputation of being a hundred years old, and to-day it is working 20 hours a day pumping, grinding, elevating and hoisting. It has no name or number plate on it. The diameter of the cylinder is 26 in., the stroke 6 ft. and the cast iron beam 18½ ft. between centres. Started with 3 lbs. of steam, at full load the steam is kept at 17 lbs. when the engine makes 20 r.p.m. It has the usual pendulum governor, is fitted with parallel motion and has a flywheel 16 ft. in diam. As originally fitted—the drawings are in the Boulton and Watt collection—the engine was a sun and planet engine designed to give 10 h.p., and payment for the engine was to be £63, annually, paid by half-yearly instalments. It is probable the engine as seen to-day has little of the original construction, and is to be regarded as a good specimen of the Watt engine improved by Murdock. It is not a little remarkable that such an engine should be at work right in the heart of the City of London, and no argument is needed to show the desirability of preserving an engine which was running before Rennie built London Bridge. Permission to inspect the engine was readily granted by Mr. H. R. Hill, the managing director of the brewery, while Mr. Harris, the chief engineer, kindly supplied some of the particulars given above.

It was the intention to publish herewith some illustrations of the Boulton and Watt collection, but photographs are not yet available for this purpose. Meanwhile, through the courtesy of Messrs. W. and T. Avery, Limited, the well known makers of weighing and testing machines, it is possible to give some interesting views of the old buildings and machinery at the historic Foundry. At the opening of the Foundry in 1796, Boulton gave a feast, and as this occupies a unique place in the history of such gatherings, the contemporary account of the proceedings may not be out of place. The building in which the "Rearing Feast" took place, is still to be seen.

"On Saturday last the 'Rearing Feast' of the new Foundry, lately built by Messrs. Boulton, Watt and Sons, at Smethwick, was given to the engine smiths and all other workmen employed in the erection.

"Two fat sheep (the first fruits of the newly cultivated land at Soho) were sacrificed at the Altar of Vulcan, and eaten by the Cyclops in the Great Hall of the Temple, which is 46 ft. wide and 100 ft. long. These two great dishes were garnished with rumps and rounds of beef; legs of veal, and gammons of bacon, with innumerable meat pies and plum puddings, accompanied with a good band of martial music. When dinner was over, the founder of Soho entered and consecrated this new branch of it, by sprinkling the walls with wine, and then in the name of Vulcan and all the Gods and Goddesses of Fire and Water, pronounced the name of the Soho Foundry, and all the people cried, 'Amen' . .

"A ball, with tea, was given in the evening to Venus and the Graces, which ended about 10 o'clock when the concluding guns were fired, and all departed in good humour."

As stated above, we publish herewith several illustrations which are of interest. Fig. 1, on page 637, shows the original offices of Boulton and Watt with the Clock Tower Gate House in which bayonets and blunderbusses were kept for the defence of the works, while Fig. 2 shows some of the cottages in Foundry Row, No. 13 on the extreme left being that occupied by Murdock till he removed to Sycamore House. Fig. 3, on the same page, is a view of a cast iron bridge over which the workmen left the Foundry.

On page 638, Fig. 4 shows the coining mint, with the barricaded windows, now used by Messrs. Avery as a smithy. Beneath the Foundry are a series of vaults, one of which is shown in Fig. 5. A tunnel leads away from the vaults, but this is now partly choked with rubbish, and its course and the purpose for which it was built are not known. The shop used for erecting the "cumbrous engines" is still in use, a view is given in Fig. 6, while Fig. 7 on the same page shows Murdock's original gasometer. An indication of the machine tools used by the firm is afforded by Figs. 8 and 9, on page 639, which respectively show an old wall drilling machine and an old slotting machine, the latter, it is believed, being the only one of its kind ever made. Both these tools have been in use for more than 60 years. The figure in the vault, Fig. 5, is that of Mr. A. W. Brown, who was apprenticed to James Watt and Co. in 1862. His father, William Brown (1822–1907), grandfather, Thomas Brown (1796–1844) and great grandfather, William Brown (1772–1820) have all been connected with the Soho Foundry.

In conclusion, it may be mentioned that some of the most interesting drawings in the Boulton and Watt collection have been lent for the time being to the Science Museum, South Kensington, where they are now to be seen in the excellent Watt Centenary Exhibition.

## STRESSES IN THIN SHELLS OF CIRCULAR SECTION.

By Professor F. K. Th. v. Iterson, Heerlen (Holland).

Some of the numerous applications of thin-walled vessels constructed of steel plates used for the storage of liquids or gases are represented in Figs. 1 to 5 on page 541. The method of calculating the stresses in such vessels is well known, and their strength, especially where the shell is curved in two directions, is surprisingly high. Equally simple, although less generally understood, is the method of calculating the stresses in thin-walled bodies subjected to bending moments, some useful applications of which are illustrated in Figs. 7 to 9. The magnitude of the stresses in such bodies is deduced from the theory of thin-walled vessels supporting internal pressure, and this theory will therefore be given in the first place.

Consider a vessel, such as that shown in Fig. 6, formed by the rotation of a curve about an axis. For an element of the shell in any position on the surface of the vessel the following notation (see Fig. 6) will be used:—

R = Radius of curvature in the meridional plane of the element.
N = Distance of the element from the axis of rotation, measured perpendicularly to the surface, and also the radius of curvature of the element in a plane perpendicular to the meridian.
$p$ = Pressure of the fluid on unit area.
$r$ = Radius of rotation.
G = Weight of fluid and part of shell inside (or outside) the circle of rotation of the element.
$\delta$ = Thickness of wall.

The theory is based on the assumption that shearing stresses in a direction normal to the surface may be neglected, but this is only allowable for parts of a shell which are thin in comparison with their area. In such cases resistance to bending may be neglected, and we need only take into account the resistance to forces acting in the plane of the surface. This will be clear if we consider the case of a model made of strong drawing paper.

Now the meridional stresses may be at once calculated from the fact that the whole weight resting on the segment below the section chosen is sustained entirely by the vertical components of the meridional stresses. Hence:

$$\sigma_m \delta 2\pi r \frac{r}{N} = G \text{ or } \sigma_m = \frac{GN}{2\pi r^2 \delta} \quad . \quad . \quad (1)$$

In this way the meridional stress $\sigma_m$ at each point of the shell of the tank represented in Fig. 6 may easily be calculated from the dimensions of the drawing. The circumferential or tangential stress $\sigma_t$ may be deduced from the equilibrium of the element while subjected to the stresses $\sigma_m$, $\sigma_t$ and the internal pressure $p$. The resultant of the two forces acting on the edges of the element in the plane of the meridian under the angle $d\alpha$ (viz., the forces $\sigma_m N d\beta \delta$) and the resultant of the two forces acting on the two other edges of the element (viz., the forces $\sigma_t R d\alpha \delta$) balance the pressure on the element, so that:

$$\sigma_m \delta N d\beta d\alpha + \sigma_t \delta R d\alpha d\beta = p N d\beta R d\alpha$$

$$\sigma_t = p\frac{N}{\delta} - \sigma_m \frac{N}{R} \quad . \quad . \quad . \quad (2)$$

The relations (1) and (2) enable the draughtsman to calculate the principal stresses for each point of the tank shell. If these stresses are of opposite sense the difference of the two principal stresses according to Guest's law, determines the strength of the plate.

This theory of tanks of circular section has proved to be reliable in the largest structures, and this fact is sufficient to justify the neglect of the very small shearing stresses normal to the surface in the thin shell of a beam of similar construction when subjected to bending moments. With this assumption the stresses in these structures can be calculated as follows:—As in the case of shells subjected to internal pressure we first calculate the meridional stresses $\sigma_m$ in planes containing the longitudinal axis and afterwards the tangential stresses $\sigma_t$. We consider only the stresses produced by transverse forces acting in a direction normal to the axis of rotation. Internal or external, fluid pressure, and forces acting along the axis of rotation, such as the weight of the structure itself, are dealt with as above described in the theory of tanks, and the stresses determined for these forces must be added to those resulting from the bending moment. The notation used is the same as in the case of the tank, and, in addition, we shall use P to designate the resultant of all the transverse forces acting on the beam or tower above the section A, Fig. 7. The meridional stresses $\sigma_m$, which, in the case of a cylinder, make up a couple, are now equivalent to a transverse force K which, on account of the inclination of the walls of the structure, acts at the intersection of the tangents with the longitudinal axis. As the moments of the forces P and K about the section at A must be in equilibrium, we get $P h = K a$. With the same approximation as is used in the ordinary bending theory of solid beams we may assume that plain sections remain plain after bending. From this it follows that the meridional stresses increase in linear proportion to the distance from the neutral axis of the section, so that at the angle $\phi$ the meridional stress is $\sigma_\phi = \sigma_m \cos\phi$. The resultant K of the meridional stresses on the section is the resultant of the horizontal components of these stresses, the vertical components for elements at equal distances from the neutral axis, and on opposite sides of that axis, cancel each other. The contribution of the stresses on any element of the section at A to the transverse force K amounts to:

$$dK = \sigma_m \sin\alpha \cos^2\phi \, \delta \, r \, d\phi$$

hence

$$K = 4\int_{\phi=0}^{\phi=\frac{\pi}{2}} \sigma_m \sin\alpha \cos^2\phi \, \delta \, r \, d\phi = \pi \sigma_m r \delta \sin\alpha$$

and as $K = P\frac{h}{a}$

$$\sigma_m = \frac{P h}{\pi a r \delta \sin\alpha} \quad \text{or as} \quad \frac{a}{\cos\alpha} = \frac{r}{\sin\alpha}$$

$$\sigma_m = \frac{P h}{\pi r^2 \delta \cos\alpha} \quad . \quad . \quad . \quad (3)$$

For a ring-shaped section, like the section at A, the shearing stresses are greatest at the neutral axis where the bending stresses are zero. At this point they amount to double the mean shearing stress over the whole section. This maximum shearing stress can be calculated from the consideration that the part of the tower above A is in equilibrium under the action of the forces P and K (which is the resultant of the bending stresses) and the shearing stresses, so that:

$$\tfrac{1}{2}\tau \times 2\pi r \delta = P - K = P\left(1 - \frac{h}{a}\right)$$

$$\tau = -P\frac{h-a}{\pi r \delta a} \quad . \quad . \quad . \quad (4)$$

From this we notice the remarkable fact that when $h > a$ the direction of the shearing stresses is opposite to that usually experienced in the case of a transverse force. It also follows that the slope of the generating curve at each point can be so chosen that the shearing stresses vanish. This observation is of considerable importance in distributing the rods in a reinforced concrete tower in the most appropriate manner, *i.e.*, only, or mainly, in planes containing the longitudinal axis. The idea of eliminating the shearing forces from each section by the shape of the outline of the tower was originally

due to M. Eiffel, of Paris, who applied it, for the first time, in the construction of his 300-m. tower at the Paris Exhibition of 1889.

The meridional stresses $\sigma_m$ are accompanied by tangential stresses $\sigma_t$. The latter may be calculated in the same way as has been shown above in the case of the tank. If there is neither internal, nor external, pressure on the element of the wall, it is kept in equilibrium by the stresses at the edges only, and we get:

$$\frac{\sigma_m}{R} = \frac{\sigma_t}{N} \text{ or } \sigma_t = \frac{N}{R}\,\sigma_m \quad . \quad . \quad . \quad (5)$$

Using formulæ (3) and (5), we next calculate the principal stresses due to the bending moments at each point of the tower. To these must be added the stresses due to axial load and to internal or external fluid pressures. The maximum shearing stresses are calculated by means of expression (4).

When a thin shell is subjected to high compressive stresses it is liable to collapse through crumpling, or folding, of the shell. In considering the factor of safety of a structure it must always be borne in mind that, for the parts or members in tension, the ultimate strength of the material must be employed, but for parts under compression, the factor of safety is obtained by considering the yield point stress of the material. The mathematical calculation of the crumpling load for a shell-shaped beam, analogous to the mathematical treatment of the crippling load for a box or ring under compression is probably only possible for very simple shapes; it may indeed be confined to the case of the cylinder. To find the factor of safety against crumpling we have therefore to make use of model experiments. When the linear dimensions of model and structure are in the ratio 1 : n the

Fig. 1. GAS BUOY.

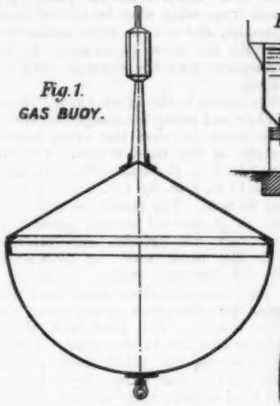


Fig. 2. CHIMNEY WATER TANK.

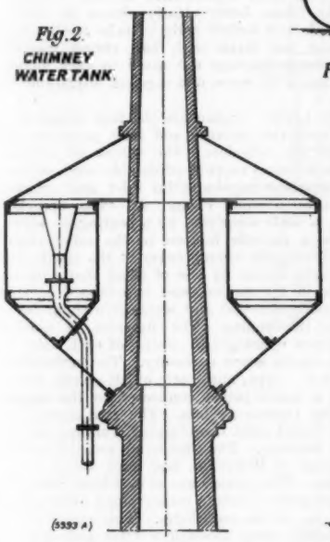


Fig. 3. GAS-HOLDER TANK.

Fig. 4. PETROL TANK.

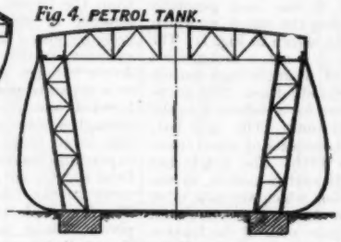


Fig. 5. SETTLING TANK FOR COAL WASHING PLANT.

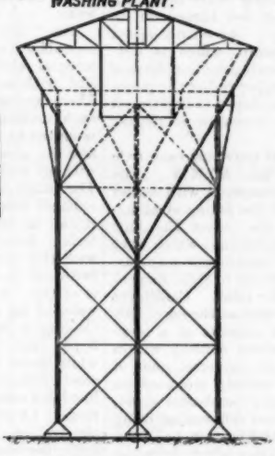


Fig. 6.

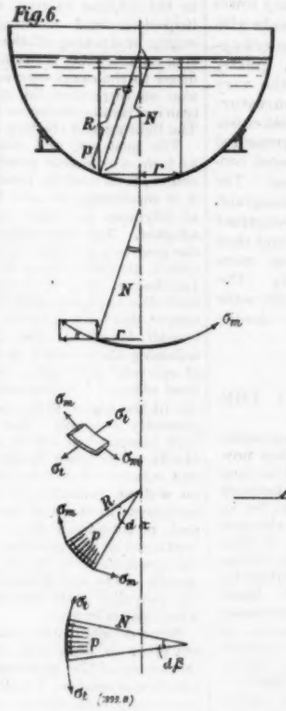


Fig. 7.

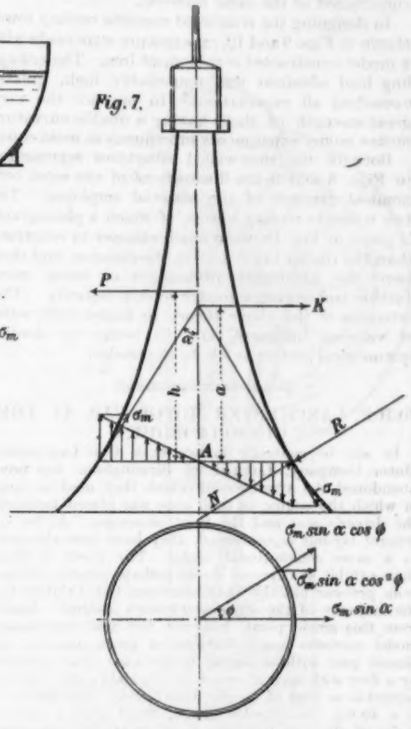


Fig. 8. FLOATING CRANE. BY SMULDERS, SCHIEDAM.

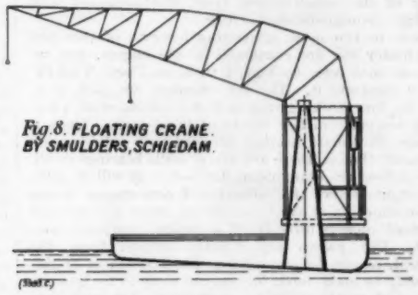


Fig. 9. FERRO CONCRETE COOLING TOWER DUTCH STATE COLLIERIES.

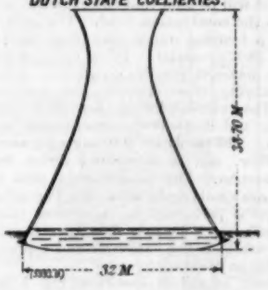


Fig. 10. Cooling Towers at Pit Emma, Heerlen, Holland.

crumpling loads will be in the ratio $P_m$: P, where $P_m = \frac{P}{n^2}$ provided that the model and structure are constructed of the same material.

In designing the reinforced concrete cooling tower shown in Figs. 9 and 10, experiments were made with a model constructed of thin sheet iron. The crumpling load obtained was remarkably high, greatly exceeding all expectations. In practice the very great strength of shells having a double curvature makes model experiments superfluous in most cases.

Both of the thin-walled structures represented in Figs. 8 and 9 are illustrations of the most economical disposal of the material employed. The two concrete cooling towers, of which a photograph is given in Fig. 10, were much cheaper to construct than the timber tower seen in the distance, and they have the additional advantages of being more durable and having a greater cooling capacity. The extension of the above theory to bodies with walls of varying thickness, and to bodies of double symmetrical section is left to the reader.

## 40-H.P. LANCHESTER MOTOR CAR AT THE OLYMPIA SHOW.

It will be generally known that the Lanchester Motor Company, Limited, of Birmingham, has now abandoned the arrangement which they used so long in which the engine of their cars was placed between the driver's seat and the front passenger. As far as general lay-out is concerned, they have now changed to a more conventional model. The result is that their exhibit at Olympia shows perhaps greater change from pre-war practice than corresponding exhibits by the majority of the other well-known makers. Apart from this single point, however, the new Lanchester model contains many features of great interest, as almost goes without saying in the case of an exhibit by a firm with such a record of originality and ability behind it as that of Messrs. Lanchester. The new car is a 40-h.p. six-cylinder model, fitted with a saloon body of the owner-driven type, and arranged with seating accommodation for four.

Some of the most interesting features of this new Lanchester car are contained in the engine, and we may at once refer to Figs. 1 to 3, on Plate XXXIV, which illustrate it. The six cylinders are each 4 in. bore by 5 in. stroke, giving an R.A.C. rating of 38·4 h.p. They are made in two blocks of three each. There is a main crankshaft bearing between each cylinder and the next, that is, there are seven main bearings in all. The pistons are aluminium, die cast. As will be seen, the engine shows the influence of aero-engine design in the adoption of overhead valves, which are operated by short rockers directly off a central overhead camshaft. The valves are slightly inclined from the vertical, as can be seen in Fig. 3. The object of this is partly to make room for the camshaft to lie between them and partly to form an approximately spherical combustion space which can be machined all over so as to ensure all cylinders having equal compression volume. From Fig. 3 it will be seen that the exhaust valve seats directly into the combustion head. The inlet valve is inserted in a housing much like that used in the Lanchester 38-h.p. model. It is claimed that this arrangement makes it possible to grind-in both valves without removing the cylinders, or disturbing the camshaft. The valves follow aero-engine practice both in form and material of construction, and have hollow stems. The camshaft also following aero-engine lines, is hollow, and is lubricated direct from the forced-feed system. The tappet lever pins are also tubular and are similarly lubricated. The adjustment of the tappets is performed by a screwed thimble on the valve end, which locates the taper bored spring collar. The whole of the camshaft and tappet gear is enclosed under an aluminium cover.

The camshaft, as will be seen from Fig. 1, is driven by a vertical spindle through the medium of skew gears. This spindle is totally enclosed. It may be said here that not only this spindle but all running mechanism throughout the whole engine, with the exception of the magneto coupling, is also enclosed. The fan and the belt driving it from the end of the crankshaft are, of course, however, not enclosed. The general lay-out of the auxiliary drives is shown in Figs. 4 and 5, on Plate XXXIV. As will be seen, the water-circulating pump is driven by a skew gear from the same wheel which drives the vertical camshaft spindle and the magneto is driven by a bevel gear operating from this latter. A Remy starting battery is fitted in addition to the magneto. The starting and lighting sets are placed in a novel position vertically on the near side of the engine. They are driven from a lay-shaft which is geared off the crankshaft and which is shown in Figs. 1 and 3. The advantage of the vertical arrangement of the starting and lighting sets is that the commutators and terminals are very accessible and that the whole of the driving gears are immersed in the oil of the crank-case. The oil pressure pump is also operated from this lay-shaft. There is an oil filter in the oil-base casting, which can be withdrawn for inspection and cleaning without dismantling the engine or drawing off the oil. The crank-case oil filler is in an accessible position, and an oil-level indicator is fitted to the crank-case on the driver's side. There is also an inspection lid through which the valve and ignition timing marks on the flywheel can be observed. The lighting and starting sets are by Lucas.

The gear-box and crank-case are bolted together to form a complete power unit. This feature has, of course, been used for some time in Lanchester cars, and it is interesting to note from the various cars shown at Olympia to what extent it has been generally adopted. The flange surrounding the clutch, to which the gear-box is bolted, is clearly shown in Fig. 1. The clutch, also well shown in Fig. 1, is a new design for a Lanchester car. It consists of a single high-tension steel disc engaging with two Ferodo discs. The adoption of this form of clutch makes for a reduction in the overall length of the power unit. The gear-box, following the maker's practice, consists of three trains of epicyclic gear and a direct drive. The weight has been reduced, as compared with earlier models, by the use of the higher grade materials which are now more generally available. The gear drums have, however, been increased in size to minimise wear of the friction blocks. The main brake is carried on the gear-box, and consists of an internal expanding brake operating on a drum provided with cooling fins turned on its periphery, in the well-known way. The change-speed gear is lubricated by a gear pump, which is self-contained in the gear-box. A small gear-box driving the speedometer is driven off the upper end of the pump spindle. The speedometer is thus driven indirectly off the propeller shaft and so reads correctly no matter what gear is in use.

Some details of the transmission gear and back axle are given in Figs. 8 to 10, on Plate XXXIV. The shortening of the power unit as compared with earlier Lanchester models, has allowed of the fitting of an exceptionally long central torque tube, which has done away with the necessity of the parallel links which have hitherto been associated with the Lanchester rear suspension. This has eliminated seven out of eight suspension joints and one carden shaft joint. Cantilever springs of the Lanchester type are used at the rear. The forward joint of the torque tube consists of a large sphere working in a phosphor-bronze housing within which is enclosed concentrically the universal joint of the cardan shaft. This joint is entirely mounted on ball bearings. The final drive is by a Lanchester worm, the detail of the gear and the bevel differential being given in Figs. 8, 9 and 10. A modification has been made in connection with the live axles which drive the rear wheels. In the older arrangement these live axles carried a portion of the bending load, as well as that due to torsion. In the present design the wheels are mounted on bearings on the tubular casing, and the live axles take torsion only. The arrangement is clearly shown in Fig. 8. This figure also shows the arrangement of the rear wheel brake drums and other details of the rear axle. Part of the front axle and a section of one of the front wheel hubs and mountings is shown in Fig. 6 and 7. These figures will be self-explanatory and require no comment.

The chassis is fitted with Rudge-Whitworth wire wheels, carrying 895-mm. by 135-mm. tyres. The wheel base is 11 ft. 9 in. and the track width 4 ft. 10 in. The front suspension is by semi-elliptic springs on orthodox lines, but the makers claim that the springs have a slower period of oscillation than is usual. The new chassis is a very attractive example of Messrs. Lanchester's work. In conclusion, it should be said that the type of carburettor to be fitted to the engine is at present undecided. A series of experiments are now being carried out with some of the best types of carburettors on the market, and Messrs. Lanchester are also designing a carburettor of their own. On the results of this work the type of carburettor to be adopted will be finally decided.

## 10-H.P. DAY-LEEDS FOUR-CYLINDER LIGHT CAR AT THE OLYMPIA SHOW.

In the figures on page 643 we illustrate one of the new light cars which is to be seen at the Olympia Exhibition. As will already have been gathered by our readers, a number of firms, hitherto little known in the motor world, have turned their attention to motor cars and are represented by their new products at the show. Many of these cars are of the lighter class and are of considerable interest as illustrating various independent attempts to produce a model which shall combine straightforward and simple manufacture with adequate robustness and efficiency. An interesting example is that shown by Messrs. Job Day and Sons, Limited, of Ellerby Lane, Leeds, which is illustrated in the figures we have already referred to and is described in this article. Not the least interesting way of considering these new cars is from the point of view of their difference from what may be looked upon as a conventional model, and it is to some points of this class that we would like more particularly to direct attention in connection with the example with which we are now dealing.

The car, which is known as the "Day-Leeds," is a two-seater, with a dickey seat which is arranged on the same level as those in front, so that the extra passenger gets the protection of the wind screen. The wheel base of the car is 7 ft. 9 in., the track 3 ft. 9 in. and the overall dimensions 11 ft. 9 in. by 4 ft. 9 in. The tyres are 700 mm. by 80 mm. The frame, as will be seen from the figures, is of channel section pressed steel, straight in plan view throughout, and braced by cross-members in the usual way. A 10-h.p. four-cylinder, 64-mm. by 100-mm. engine, is fitted, and drives through an internal leather-faced cone clutch to a separate gear-box, the gears giving three speeds forward and one reverse. The back axle drive is through a bevel gear and bevel differential. Foot and side lever brake controls are fitted, both operating expanding brakes on the rear hubs. Both back and front springs are semi-elliptic, their method of attachment to the frame being clearly shown in Fig. 2. The front axle has forked ends to take the steering pivots, which are fitted with ball thrust washers. Two ball journal bearings are fitted to each spindle hub. Steering is by worm and segment adjustable for wear.

The "Day-Leeds" engine has the four cylinders in monobloc, with the exhaust and inlet passages cast integral with the cylinders. The valves are of large size, with nickel-steel tappets adjustable and enclosed. There are separate camshafts for inlet and exhaust, each driven by a roller chain. An extra sprocket, mounted on a shaft supported by a bearing, is adjustable to give a suitable tension to the roller chains without removing the timing cover of the crank-case. The magneto is driven by one of these shafts on the exhaust side of the engine, and is arranged so that it can be easily removed and replaced without interfering with the timing. The flywheel is marked with the correct opening and closing of each valve to facilitate re-timing when necessary. The carburettor is of the "S.U." type, automatic at all speeds, and is warmed by a water jacket connected to the engine. Cooling is by thermo syphon. The crankshaft is a 3 per cent. nickel steel drop-forging, running in two white metal bearings. The connecting rods are nickel-steel stampings of H-section, and have white metal-lined big-ends. The pistons are of cast-iron, with two rings. Lubrication is from a rotary pump driven from the end of one of the camshafts. This pump draws from the engine sump through a filter and delivers to two pipes, one of which is provided with fine holes through which the oil is sprayed on the camshaft driving chains. The other pipe, through which the bulk of the oil passes, delivers to oil troughs fixed below the crankshaft. The big-end caps are provided with scoops, which dip into these troughs and conduct the oil to the big-end bearings. The crankshaft and camshaft bearings are lubricated by means of ducts which catch the oil splashed by the rods. Oil is introduced to the engine by a vertical pipe leading to the sump, and a priming cock is provided for the sump.

Turning now to some further details of the transmission, it will be seen from the figures that the gear-box is attached to two of the cross-members of the frame. The attachments are such as to give a three-point suspension. The change-speed control is by gate, and the casing supporting the selector levers, and the change-speed and side brake levers, forms a complete and independent unit. It is bolted to the underside of the side members of the main frame, and is spigotted to the side of the gear-box with an oil-tight joint. This arrangement allows full freedom of the selector shafts without interfering with the three-point suspension of the gear-box. At the rear end of the gear-box there are two bosses cast on which take pins, upon which the fork at the end of the tube enclosing the propellor shaft is pivoted. These pivots are in line with the universal joint centres. The arrangement is clearly shown in Fig. 1. Power is transmitted from the clutch to the gear-box by a shaft castellated at one end. Leather disc couplings allow for mal-alignment due to uneven road surfaces. When engaging and withdrawing the clutch one of the flexible joints slides on the castellated part of the shaft. The bevel final drive and the bevel differential gears are made of hardened nickel steel, and are contained in an aluminium casing to the sides of which the axle tubes are bolted. The bearings for the brake-operating cams are integral with these tubes. Extensions of these tubes carry two ball journal bearings for each rear hub. The differential box is supported on two ball journal bearings and held in

# 10-H.P. FOUR-CYLINDER LIGHT MOTOR CAR AT THE OLYMPIA SHOW.

CONSTRUCTED BY MESSRS. JOB DAY AND SONS, LIMITED, ENGINEERS, LEEDS.

(*For Description, see opposite Page.*)

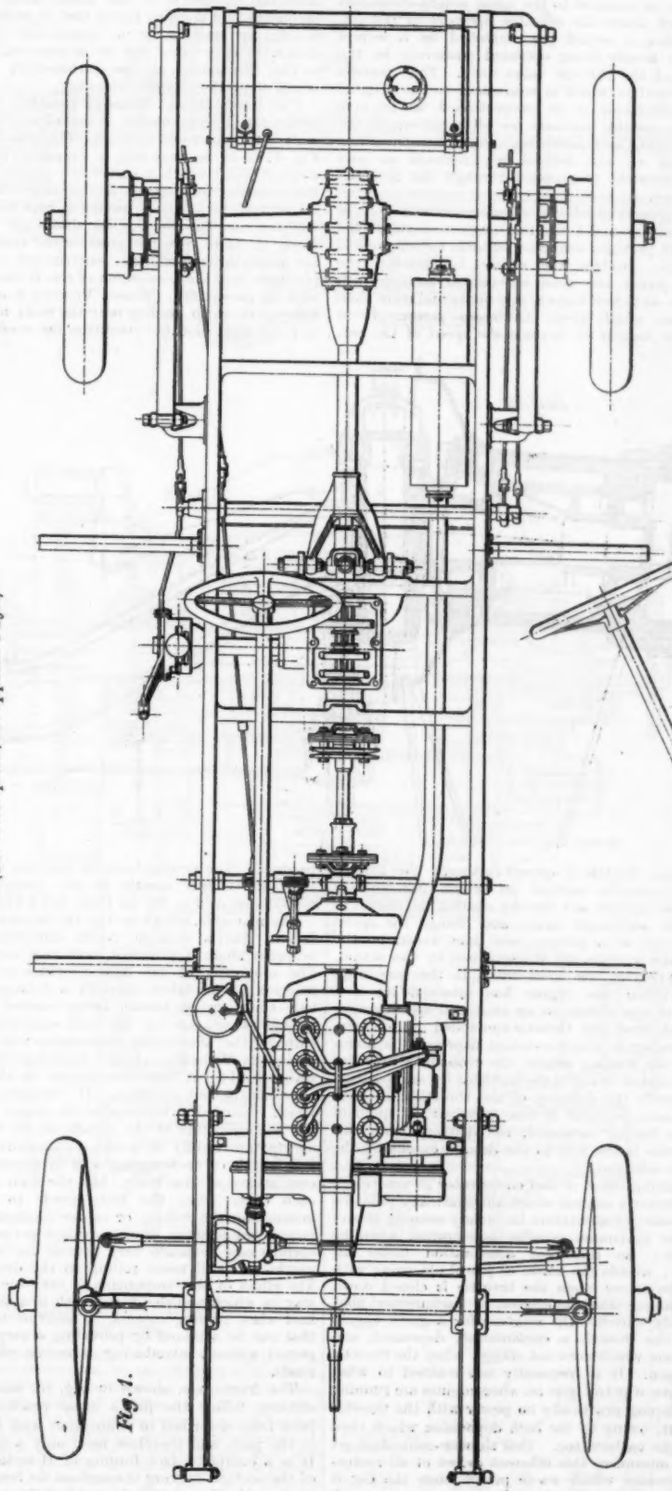


*Fig. 1.*

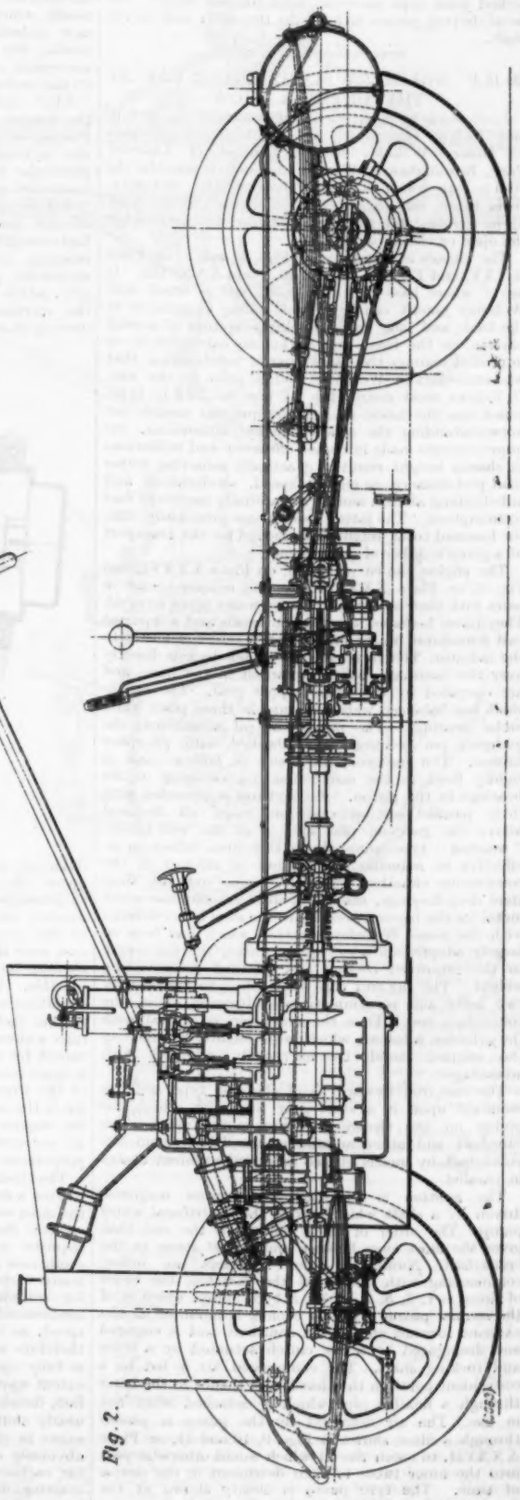


*Fig. 2.*

position by ball thrust washers. Two pinions are mounted on a solid pin through the casing. The propeller shaft is carried by a flanged tube bolted to the aluminium casing. The shaft is mounted on ball journal bearings and is kept in its correct position by a double thrust ball washer. It is made of nickel steel, and is castellated at the gear-box end for the forked joint type universal joint to slide upon. The bevel-driving pinion is fixed to the other end of the shaft.

## 20-H.P. WOLSELEY SIX-CYLINDER CAR AT THE OLYMPIA SHOW.

Last week we illustrated and described the 10-h.p. and 15-h.p. cars which are exhibited at Olympia by Messrs. Wolseley Motors, Limited, of Adderley Park, Birmingham. We now propose to describe the 20-h.p. car which is shown by the same company. It is fitted with a six-cylinder engine, 3½ in. bore, 5½ in. stroke, and has been designed to carry either the open or closed carriages.

The chassis is illustrated in Figs. 1 and 2, on Plate XXXV, and Figs. 12 and 13, on Plate XXXVIII. It has a wheel base of 11 ft. 5 in., and is fitted with Wolseley patent cantilever anti-rolling suspension at the back, and long flat semi-elliptic springs of normal pattern on the front axle. This car carries on in an improved manner the same type of construction that was embodied in Wolseley models prior to the war. It follows most nearly the 24 h.p. to 30-h.p. type, which was the latest six-cylinder pre-war model, but notwithstanding the smaller engine dimensions, the improvements made in engine efficiency and reductions in chassis weight result in it actually achieving better road performance, as regards speed, acceleration, and hill-climbing ability, and on a materially improved fuel consumption. The latter result arises principally from the lessened total weight to be moved for the transport of a given number of passengers.

The engine shown in Fig. 3, on Plate XXXVI, and Fig. 4, on Plate XXXVII, has the cylinders cast in pairs with their water jackets and water pipes integral. They have L-shaped combustion heads and a separate cast aluminium water pipe forms a common return to the radiator. The valves are placed side by side directly over the camshaft, which is carried in the base, and are operated by the usual tappet gear. The crankshaft has balanced webs and runs in three plain white metal bearings. The pistons are of aluminium, the gudgeon pin bearings being bushed with phosphor bronze. The gudgeon pin itself is hollow, and is rigidly fixed to the connecting rod swinging in the bearings in the piston. Each piston is provided with three parallel section cast-iron rings, all disposed above the gudgeon pin, and is of the well-known "waisted" type adopted by this firm, which is so effective in reducing the amount of oil lost in the combustion chamber. The connecting rods are alloy steel drop-forgings, machined all over, and the white metal for the big-end is cast into the steel in accordance with the usual Wolseley practice, which has been so largely adopted on aero engines during the war owing to the improved cooling and lessened reciprocating weight. The big-end cap is attached to the rod by two bolts and is symmetrically disposed about the connecting rod. Thus the crank-pin is central with the cylinder, a feature which, while slightly lengthening the engine, could be universally adopted with advantage.

The cast-iron flywheel is of the disc type and has mounted upon it a steel gear ring with which the pinion on the electric starting motor gears. The camshaft and other auxiliaries are driven from the crankshaft by means of two independent silent chains in parallel.

The ignition is by dual high-tension magneto, driven by a shaft which carries the centrifugal water pump. The order of firing adopted is the one that gives the most even balance and lowest stress in the crankshaft. Numbering the cylinders in order, commencing with No. 1 at the radiator, the order of firing is 1, 3, 5, 2, 4, 6. A tyre pump, which is of the normal piston type, air cooled, is mounted at the extreme forward end of the camshaft and is engaged and disengaged by a jaw clutch actuated by a lever and rocking shaft. The compressed air is led to a convenient point on the chassis and thence to the tyres through a flexible pipe which is detached when not in use. The air delivered by the pump is passed through a filter, shown in Figs. 9, 10 and 11, on Plate XXXVII, to catch the oil which would otherwise pass into the inner tubes to their detriment in the course of time. The tyre pump is clearly shown at the forward end of the engine in Fig. 3.

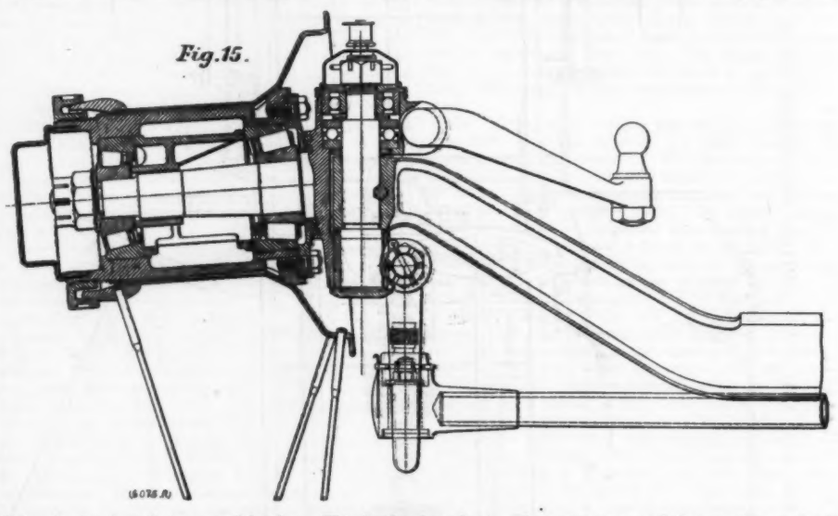
The carburettor is an interesting development. It is of the same type as the firm are now fitting to the 15-h.p. model. It was briefly referred to last week, and is now illustrated in detail in Figs. 5 to 8, on Plate XXXVII. The Wolseley Company were one of the first motor-car manufacturers to take up the "S.U." carburettor, which they have fitted as standard to their models for several years past, the carburettors used embodying a special feature which was introduced by the firm before the system was adopted. For the models under review, a further and radical modification has been made with a view to overcoming the shortcomings which have always been well known. The carburettor, in addition to the usual weight-controlled needle which alters the effective aperture of the jet, now embodies a second jet controlled by a second needle, this needle being operated positively by the movement of the throttle valve itself. That portion of the carburettor which is equivalent to the original "S.U." carburettor is so proportioned as to give the leanest possible mixture for all positions of the floating weight, and additional petrol to strengthen the mixture to the desired requirements at any particular moment is supplied through the throttle-controlled jet.

For the normal speed of the engine under any given throttle position and load, this augmentation of the fuel strength provides a mixture suitable for economical running, *i.e.*, enables the engine to develop the maximum power the most economical mixture will give, which, as is well known, is a weaker mixture than the mixture which gives maximum power. If in driving it is desired to increase the speed of the car, obviously the throttle is opened further. This further opens the throttle control jet which immediately enriches the mixture and thereby enables the engine to develop the additional power and change the speed of the vehicle at a greater rate than would be the case were the mixture not strengthened by this action, thereby improving the acceleration to the maximum possible. When the engine has attained its new condition of equilibrium at an increased speed, owing to the fact that the throttle-controlled jet delivers into a chamber in which constant depression is maintained by the floating weight, the economical mixture is again provided owing to the fact that for any position of the throttle the delivery of the throttle-controlled jet is the same per unit of time, whereas the speed of the engine having increased, the delivery from this jet per stroke is lessened to the desired extent by the proportions adopted.

The resulting effect of this carburettor in practice is to give a driver a control which automatically provides the most economical mixture for steady running at any speed; the maximum possible acceleration when he requires it; an improved acceleration under all conditions; avoids the waste of petrol obtaining with many carburettors when the throttle is closed down for retarding; and, moreover, a carburettor that continuously enriches the mixture for a given engine speed, as the throttle is continuously depressed, and therefore one which does not stagger when the throttle is fully open. It is frequently not realised to what extent waste of petrol goes on when engines are running fast, developing practically no power with the throttle nearly shut, owing to the high depression which then exists in the carburettor. This throttle-controlled jet obviously minimises this inherent defect of all motor-car carburettors which waste petrol when the car is coasting down a gradient with the engine engaged. It is well known that the introduction of heavier fuels on account of the greater increased demand for petrol has necessitated the employment of fuels of higher specific gravity and boiling-point. This has introduced difficulties in starting when the engines are cold. To overcome this difficulty, this carburettor employs what is in fact a very small carburettor which is only in action under starting conditions, and comprises a small by-pass passage which crosses the main jet and enters the main mixture pipe against the leading edge of the butterfly throttle. By this means, when the throttle is nearly closed, a very sharp suction is provided on the jet nozzle, so that while the strength of the mixture is substantially unchanged, the degree of atomisation, which is the main thing required to carburate cold air with heavy fuel, is greatly enhanced, facilitating starting to a considerable extent. The details to effect this will be understood by reference to the illustration of the carburettor, Figs. 5 to 8, which show the auxiliary passage.

The clutch follows Wolseley practice, as referred to under the 15-h.p. model, being of the fully-enclosed multi-disc type running in oil. The gear-box, shown in Fig. 17 to 19, on page 645, is a separate unit driven by a clutch shaft which is universally jointed. This gear-box provides four speeds and reverse. The gears are made from nickel steel having a high nickel content, and are case-hardened. The shafts are also of alloy steel, in fact, very few steels other than alloy steels are used throughout the construction of this firm's products, and the association of the Wolseley Company with its parent firm (Messrs. Vickers) is utilised to the fullest extent to employ only the most suitable steels in their most suitable condition for every part of the product. The arrangement of the gear-box and controls are shewn clearly in the photographic view reproduced in Fig. 14, on Plate XXXVIII.

*Fig. 15.*



The rear axle, shown in Fig. 16, on page 645, is worm driven, has a straight tooth differential, and the propeller shaft is provided with two universal joints. The mounting of the axle provides for the torque reaction to be taken through a triangulated torque bar, the forward thrust being carried through the springs which are of the full cantilever type and embody the anti-rolling suspension which was introduced on Wolseley vehicles immediately prior to the war in 1914. A brief description of this suspension may not be out of place. It comprises a cross bar which is carried in bearings in the frame, and to which the anchor points at the middle of the full cantilever springs are rigidly attached. This provides that the full length of each spring acts in unison for vertical oscillations of the body, but the two springs resist each other when the body tends to roll, thereby minimising the rolling, or rather rendering the rolling period independent of the vertical period so that the springs can be made very flexible for vertical movements and still resist rolling to the desirable extent. The effect of this suspension is very noticeable in the way in which vehicles fitted with it maintain an even keel when turning corners, in addition to the comfort that can be attained by providing a very slow vertical period without introducing excessive rolling on rough roads.

The front axle, shown in Fig. 15, annexed, and the steering follow the firm's usual practice, which has been fully described in connection with their products in the past, and therefore need only a brief reference. It is a complete drop-forging of H-section, the width of the section varying throughout its length in accordance with the distribution of stress. The steering pivots are provided with ball bearings, and the hubs themselves run on Timken bearings. The steels used for the various parts of the axles and steering gear are, as already stated, all products of the parent firm, their axle steel being extensively used, the most suitable material being selected for each part and heat-treated to get the most desirable physical properties.

# 20-H.P. WOLSELEY MOTOR CAR AT THE OLYMPIA SHOW.

CONSTRUCTED BY MESSRS. WOLSELEY MOTORS, LIMITED, ENGINEERS, BIRMINGHAM.

(*For Description, see opposite Page.*)

*Fig. 16.* OFF SIDE.

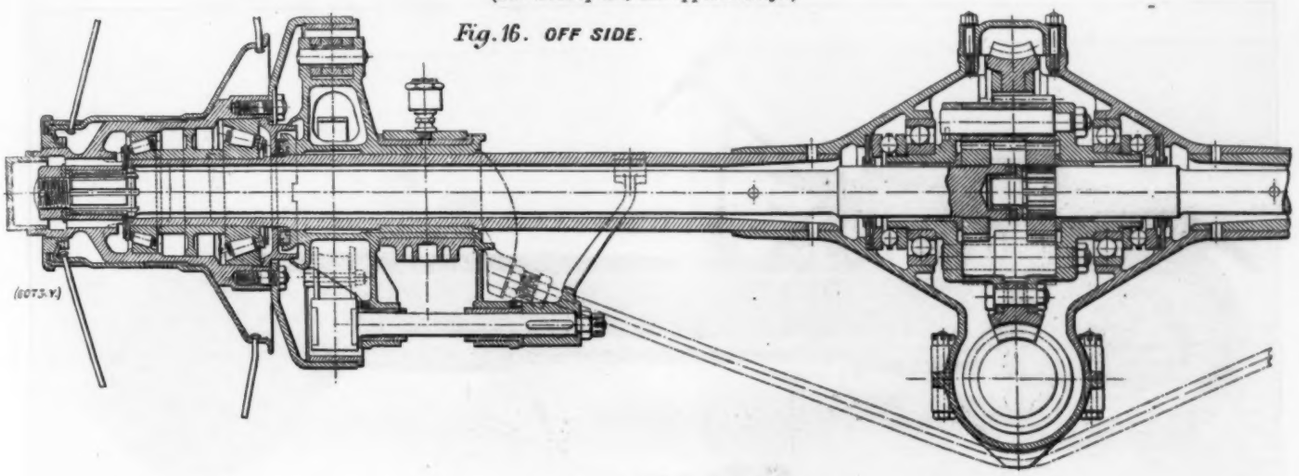


*Fig. 17.*

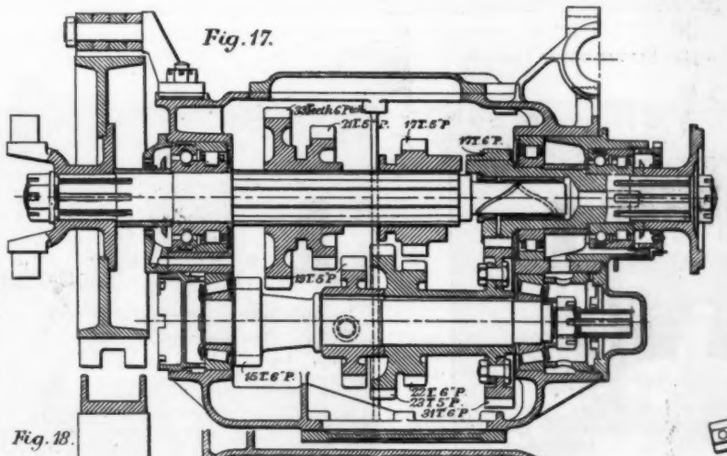


*Fig. 18.*

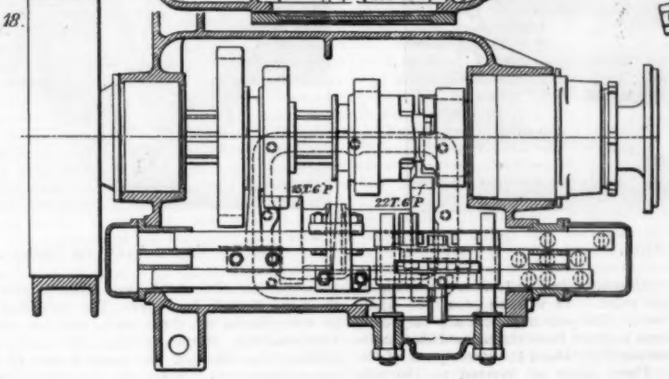
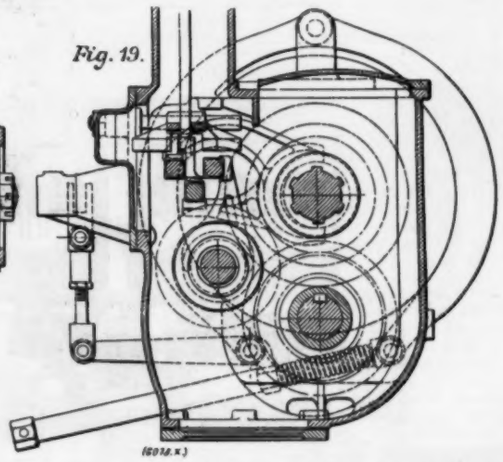


*Fig. 19.*



## PIG-IRON AND STEEL OUTPUT AND EXPORTS.

THE collection of statistics of output of pig-iron and steel which was undertaken by the Ministry of Munitions during the war for administrative purposes, is being continued by the National Federation of Iron and Steel Manufacturers. The first return issued by the federation related to the month of August, and replies were received from firms who in the first quarter of the year were responsible for 95 per cent. of the total output of pig-iron and 92 per cent. of the output of steel. In September, the proportion of replies received was 90 per cent. and 91 per cent. respectively. On this basis it may be taken that the output of pig-iron in August amounted to about 521,000 tons, and in September to 574,000 tons. The output of steel in August was about 474,000 tons, and in September, 718,000 tons. The following table (the figures being in thousands of tons), compares the output of pig-iron and steel in each month of this year and in 1913, with production in United States and Germany :—

| | United Kingdom. | | Germany. | | U.S.A. | |
|---|---|---|---|---|---|---|
| | Pig-Iron. | Steel. | Pig-Iron. | Steel. | Pig-Iron. | Steel. |
| 1913, average monthly .. | 855 | 639 | 1,582 | 1,502 | 2,581 | 2,608 |
| January .. | 664 | 718 | 499 | 550 | 3,306 | 3,698 |
| February .. | 625 | 734 | 469 | 516 | 2,940 | 3,219 |
| March .. | 684 | 758 | 551 | 635 | 3,090 | 3,168 |
| April .. | 653 | 668 | 434 | 428 | 2,478 | 2,665 |
| May .. | 662 | 755 | 517 | 594 | 2,108 | 2,296 |
| June .. | 612 | 631 | 519 | 631 | 2,115 | 2,641 |
| July .. | 660 | 618 | 572 | 785 | 2,429 | 2,985 |
| August .. | 521 | 474 | 561 | 729 | 2,743 | 3,269 |
| September .. | 574 | 718 | 524 | 726 | 2,488 | — |
| October .. | — | — | — | — | 1,864 | — |

It will be seen that in all three steel-producing countries and especially in the United States, the production in the second quarter was lower than in the first; but in the United States production was recovering in August, while in the United Kingdom, owing to the Yorkshire coal strike, holidays and other causes, the production was lower than any month this year, and less even than the production of Germany. The October figures of output of pig-iron in the United States just to hand, show, as was to be expected, a big decline. The United States of America output figures for steel are delayed owing to the strike.

The following table shows (also in thousands of tons) the exports of iron and steel from the United Kingdom and the United States :—

| | United Kingdom. | | U.S.A. | |
|---|---|---|---|---|
| 1913, average monthly | Pig-Iron. 93·7 | Steel. 317·4 | Pig-Iron. 23·9 | Steel. 217·0 |
| January .. | 34·9 | 134·1 | 36·7 | 283·7 |
| February .. | 21·8 | 86·2 | 20·8 | 295·1 |
| March .. | 21·3 | 136·7 | 22·2 | 318·5 |
| April .. | 24·6 | 146·4 | 17·0 | 362·6 |
| May .. | 23·9 | 182·1 | 37·1 | 332·4 |
| June .. | 27·8 | 166·2 | 39·8 | 475·0 |
| July .. | 23·4 | 166·6 | 42·2 | 284·2 |
| August .. | 30·3 | 181·2 | — | — |
| September .. | 32·4 | 156·6 | — | — |

The exports from the United Kingdom were thus less than 50 per cent. of the pre-war exports, whereas in the first half of the year the exports from the United States were 50 per cent. in excess of pre-war exports. Moreover, whereas before the war the exports of iron and steel from the United States were about 60 per cent. of those from the United Kingdom, in the first half of this year they were con iderably more than double those of the United Kingdom. The decline in United States exports in July is attributed to strikes at the docks and the exchange situation. Later figures will be awaited with interest.

# 29·5-H.P. SIX-CYLINDER MOTOR CAR AT THE OLYMPIA SHOW.

CONSTRUCTED BY MESSRS. ARMSTRONG SIDDELEY MOTORS LIMITED, ENGINEERS, COVENTRY.

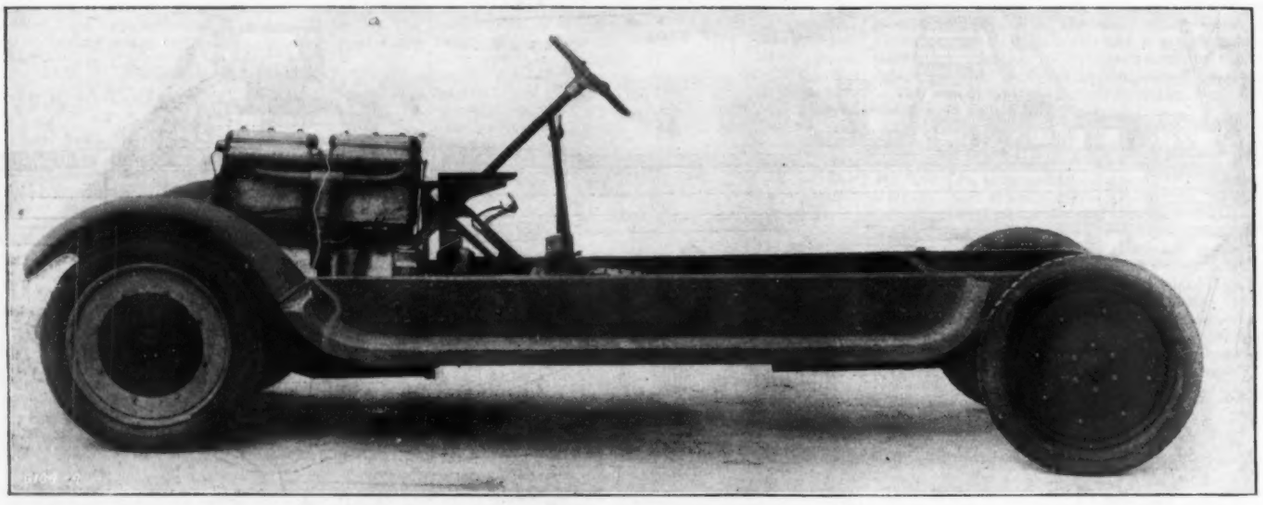


FIG. 1. ELEVATION OF CHASSIS.

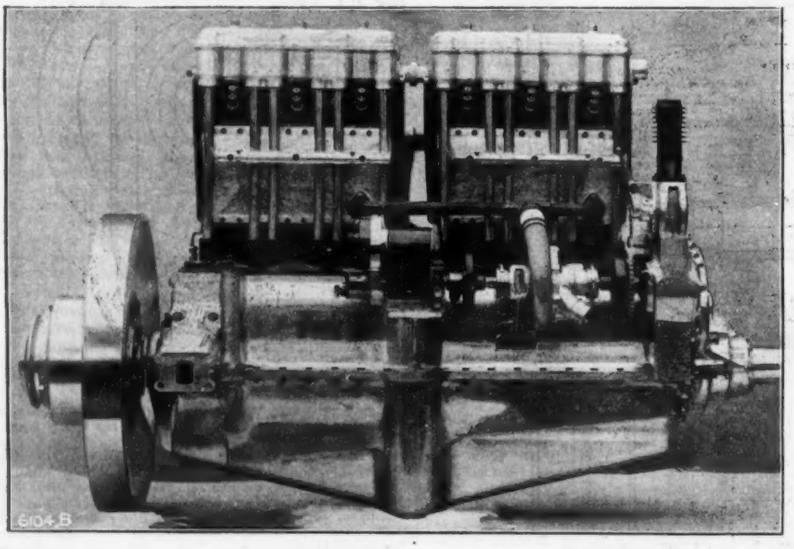



FIG. 2. VIEW OF ENGINE: VALVE SIDE.

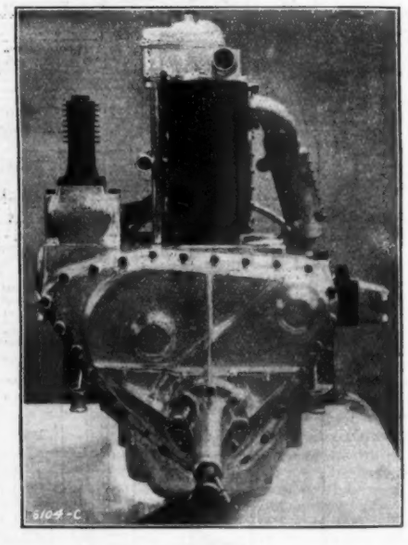



FIG. 3. FRONT VIEW OF ENGINE.

ONE of the most interesting cars at Olympia is that exhibited by Messrs. Armstrong Siddeley Motors, Limited. This new company represents a fusion of the interests of the Siddeley-Deasy Motor Car Company, Limited, of Coventry, and the motor department of Messrs. Sir W. G. Armstrong, Whitworth and Co., Limited. This strong combination should be capable of taking and holding a good position in the motor car world, and their present proposals are not lacking in boldness or interest. It is proposed to build only one type of chassis and to manufacture on lines of mass production. Unlike some other attempts in this direction, however, it is not proposed to make either a light or medium-sized car, but boldly to bring forward a six-cylinder chassis, with an engine capable of an output of 60 h.p., and suitable for carrying a five- to seven-seater body, depending on the type. This high-class chassis is to be retailed at the remarkable price of 720*l.* complete with self-starter, electric-lighting set, lamps, &c. This price is little more than half of that asked by many makers for a chassis of similar power. The car bodies supplied with the standard chassis are to be built by the Burlington Carriage Company, Limited, a subsidiary organisation of Messrs. Armstrong Siddeley Motors. Arrangements are in hand for an output of 5,000 cars a year.

The chassis is illustrated in Fig. 1, above, and Fig. 6, on the opposite page. As will be seen, the frame is of unusual form. The side members are very deep and receive lateral support from the pressed-steel units forming the running boards and the lower parts of the mud-guards. These units are riveted to the side members. In plan, the frame tapers outward from the front end to a point over the centre of the rear suspension cantilever spring and then inward to a back cross-member. At its widest point, the frame is braced by another cross-member to which the centres of the cantilever springs are secured. The frame is so wide at this point that the springs are arranged inside it. This unusual width, by affording good support to the body, enables weight to be saved in the body framework. The front springs are of the semi-elliptic type, and are supported at their rear end inside the frame by shackles hung to inwardly-projecting brackets. There are altogether four cross-members to the frame, the other two being one at the front of the engine and one between the engine and gear box.

The engine has six cylinders each 3¼-in. bore by 5½-in. stroke, giving an R.A.-C. rating of 29·5 h.p. It is guaranteed to develop 60 brake horse-power. Overhead valves are employed, arranged all on one side of the engine and operated by push rods from a camshaft in the crank-case. The engine is shown in Figs. 2 and 3, above. The cylinders are made in two blocks of three each and are of cast-iron. Comparatively simple castings have been secured by making the sides of the water-jacket of aluminium cover plates and forming the top water spaces in the separate aluminium head casting. This question of simplifying castings for motor-car work appears to us to be of importance. If the many large building programmes now in being are successfully carried forward, it is not impossible that the question of an adequate supply of the more intricate castings may prove a difficulty. The jacket cover plates incidentally have the advantage that their removal enables the interior of the jackets to be easily cleaned if, for instance, they have become furred through the use of hard water. The valve seats and stem guides are shrouded by the cooling water, which assists in preventing distortion.

As will be seen from Fig. 2, the valve gear is completely enclosed. The push rods are also enclosed in aluminium tubes, which extend down to the valve tappet guides. The tappets are plain-ended and the camshaft is solid. It is carried on three bearings. The overhead valve rockers are pressure lubricated, and from these rockers the oil drains down the push-rod tubes on to the cams, and so back to the engine sump.

# 29·5-H.P. SIX-CYLINDER MOTOR CAR AT THE OLYMPIA SHOW.

CONSTRUCTED BY MESSRS. ARMSTRONG SIDDELEY MOTORS LIMITED, ENGINEERS, COVENTRY.

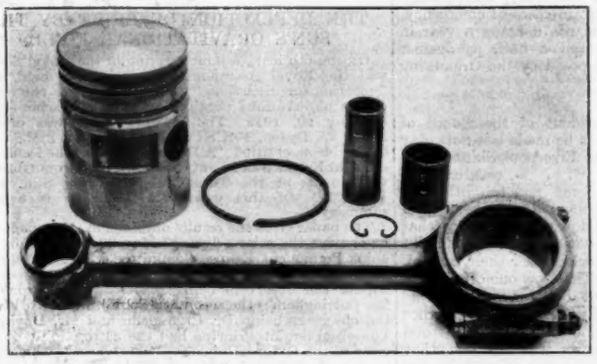


FIG. 4. CONNECTING ROD AND PISTON DETAILS.

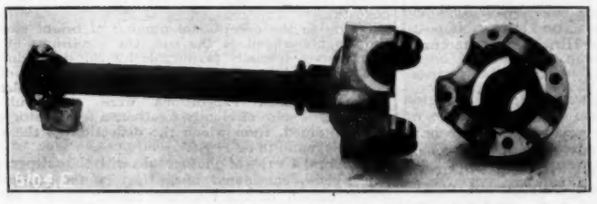


FIG. 5. CLUTCH SHAFT AND UNIVERSAL JOINT.

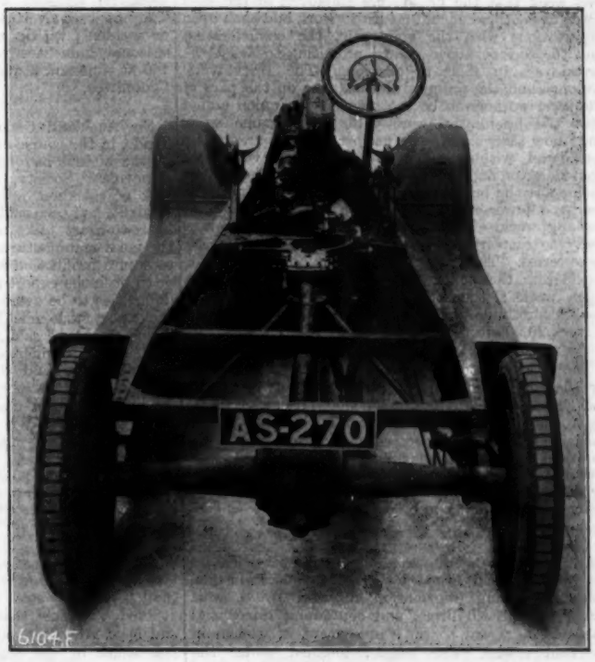



FIG. 6. CHASSIS FROM REAR END.

The engine crankshaft has three main bearings, and is unusually stiff. To reduce weight, the crank-pins and journals are drilled and the ends of the holes are closed by steel caps. These passages through the crankshaft are put in communication with oil holes drilled through the webs and are used for lubrication purposes. The connecting-rods are tubular and are machined all over to ensure good balance. The big-ends have white metal run in, while the small ends have phosphor-bronze bushes for the hollow gudgeon pins, which are free to oscillate either in the piston bosses or the small-end bearings. Lateral movement is prevented by wire rings sprung into grooves. The pistons are of cast-iron and carry three rings each. Details of these parts are shown in Fig. 4, above.

Lubrication is from a gear pump located in the oil sump, and thus requiring no priming. It is driven by a vertical shaft and skew gears from the camshaft. The pump delivers through a filter to the crank-shaft journals and thence through the hollow shaft to the big ends. The pistons are lubricated by the excess of oil thrown off by the big ends. The camshaft bearings are fed direct by pressure. As before mentioned, the overhead valve gear is also lubricated from the pressure system. The auxiliary drives are by silent chains, one driving the camshaft and another the water pump and magneto on the off-side. A flexible and adjustable coupling is placed between the chain sprocket and the pump, and another is placed between the pump and magneto. This latter may be adjusted to vary the time of ignition. These arrangements may be seen in Fig. 2. Provision is made for operating a mechanical tyre pump, a pinion being mounted at the back of the distributing case for the purpose. The pump can be seen in Figs. 2 and 3. Electric lighting and starting sets are fitted. The dynamo is belt-driven, while the starting motor, which is placed on the left side of the crank case behind the distributing gear, drives the front end of the crankshaft through a roller chain and free-wheel clutch. The chain is only in operation during the actual process of starting the engine.

The induction manifold of the engine is exhaust-jacketted to assist vapourization, while the exhaust manifold has its outlet at the front end and leads to an expansion chamber situated in front of the axle. From this chamber a pipe leads to the silencer. This arrangement tends towards the reduction of sound by cooling the gases considerably before they reach the silencer. It also keeps the heat from the exhaust away from the front-seat space. The fly-wheel has vanes on its periphery and serves as a fan. The clutch is of the multi-plate dry type. From the clutch the drive is taken through two universal joints to the three-speed gear box. The foremost of these joints, which lies actually within the clutch, consists of three steel balls sunk within the spherical head of the coupling shaft, the outstanding half of each ball engaging with a groove in the driven member of the clutch. This joint provides universal and telescopic movement, the latter being required when the clutch pedal is operated. The rearmost joint, which forms the main universal joint of the transmission, is of the star pattern with ball-bearings. It is lubricated from the gear box. The connecting rod, showing these clutches, is illustrated in Fig. 5, above.

The method of supporting the gear-box is unusual. It has an aluminium casing which is bolted directly to a flange at the head of the propeller shaft tube. The two parts together are supported by a ball joint in a bracket secured to the central cross-member of the frame. This method of supporting the gear-box, besides eliminating one universal joint, isolates it from the effects of frame distortion. The arrangement which can be seen in Fig. 6, results in a very compact arrangement. The gear box in itself is a very compact unit. This is attained to some extent by extending the spigot of the driving shaft through the hollow-driven shaft. From the point of view of whip, this makes the driving and driven shafts practically one. The spigot is supported by roller bearings at each end. This arrangement cuts out certain bearings and shortens the overall lengths of the shafts. The rear-end of the driver shaft is carried on roller bearings, and is flanged for bolting to the forward end of the hollow propeller shalt. The lay shaft is also hollow, and is secured from rotating in the bottom of the box, the gear wheels which it carries being provided with phosphor-bronze bushes which either rotate in the wheels or on the shaft itself. The gears are operated by a centrally-placed lever working in a gate secured to the central cross-member of the frame. The gate casting, which is of aluminium, also forms the support for the hand-brake lever, while a forward extension encloses the pedal of the engine starter switch.

The front end of the propeller shaft carries a helical pinion for the speedometer drive, enclosed within an extension of the gear-box, while to the rear end is secured the driving pinion which forms the final transmission. The bearing supporting this pinion has its inner race mounted on the boss of the pinion itself, so that the latter receives support immediately behind its teeth. End thrust is provided for by a double-ball thrust washer, which can be adjusted from outside the propeller shaft casing. The rear end of this casing is bolted to the aluminium centre of the axle casing, while the natural stiffness of the axle and shaft unit is increased by diagonal rods running from a point behind the gear-box to the outer ends of the axle casing. These rods can be seen in Fig. 6. The extensions of the aluminium axle centre consist of tapered steel castings which support the road wheels on a single ball-bearing at each end. The axle is thus of the semi-floating type, the second bearing for each wheel being that arranged at the side of the differential. The driving shafts are tapered and are secured to the wheels at their outer ends and the sun wheels of the differential by a combination of splining and plain taper.

There is another special feature of the chassis in connection with the detachable wheels. These are of the single disc type, the disc being welded to the outer edge of the tyre rim and having a large central hole. In the case of the back wheels the brake drum is secured to the disc by studs and nuts, while the front wheels have a studded disc extension of the same diameter as the rear wheel brakes. The wheels are thus made interchangeable. The disc wheels are so built that overhang of both front and rear axle bearings is avoided, for the centre of the bearings in each case coincides with the vertical centre line of the wheel. This gives centre steering on the front wheels, the vertical steering pivot within the dished wheel being immediately over the point of contact of the tyre with the ground. The wheels thus always tend to run in the direction in which they are set, and the steering connections are relieved from shocks which they would otherwise experience. The steering gear is of the worm and complete worm-wheel type, enabling the worm wheel to be moved to a fresh point of engagement when it is worn.

SODIUM CARBONATE MANUFACTURE IN CANADA.—Glass manufacturers in Canada have been largely dependent in the past upon the United States for their supplies of glass sand and sodium carbonate. However, according to the United States Bureau of Mines Report, the new plant at Amherstburg, Ontario, Canada, at which sodium carbonate is to be made by the Solvay process, is expected to supply all of Canada's needs for soda ash. The capacity of this plant is reported to be about 120 tons per day. Some glass sand is being secured from Oneida, Ontario, but it is said to be of an inferior grade, and only suitable for the manufacture of the cheaper grades of glassware.

## INDUSTRIAL NOTES.

The branches in Scotland of the Iron and Steel Trades Confederation and of the Amalgamated Society of Steel and Iron Workers, many of whose members have been thrown out of work by the closing down of steel works owing to the bricklayers' strike, proposed last week that the bricklayers employed in the steel trade of Scotland should return to work and then open negotiations with the employers, the confederation and the society above named promising to assist the bricklayers in their negotiations. The Bricklayers' Union found the promise of assistance on the part of the steel workers to be too vague; the union added that the bricklayers were willing to resume work and allow their claim for a 9*d*. per hour increase to be considered within seven days, provided the Steel Confederation and the Steel Society pledged themselves to support the bricklayers to the utmost in refusing to accept a lower minimum rate than 5*l*. per nominal working week. The bricklayers declared themselves ready to reopen negotiations with the employers on these terms. The Steel Confederation and Society are considering the point. The dispute has now lasted seven weeks; the strike of 400 bricklayers in the Lanarkshire and Ayrshire steel works has thrown out of work 20,000 iron and steel workers.

The *Sole* of October 4 reports that the negotiations for the conclusion of a labour treaty between Italy and France have resulted in the signature of an agreement which will be submitted for approval to the Parliaments of the respective countries. The treaty contains 26 clauses, and regulates labour relations between the two countries arranging so far as possible for equality of treatment as between immigrants and nationals in all that concerns the provision of benefits and assistance.

A report on Women in Engineering and other Trades has recently been issued by the Women's Industrial League, covering information received by a large number of British firms, and containing tables and statistics in regard to the employment of women in the said trades. The league, founded under the presidency of Lady Rhondda as soon as hostilities ceased, has for its object to secure equality of treatment and opportunity for the employment of women. The report shows that 79,700 women were employed in various industries at the end of May, 1919, as compared with 245,300 during the war, and the letters received from the firms concerned showed that they were highly satisfied with women's work. The league states that a third of the firms who employed women for the first time during the war have been able to retain them on some processes, and a further third would be willing to keep them on but for the opposition made to such a policy. Another reason given as a factor militating against the retention of women is said to be the introduction from time to time by Government of legislation to "protect" women workers. The Women's Industrial League is asking for equality of treatment, which, it adds, can be the only successful solution of the problem on economic grounds as well as on those of justice.

The report, dated October 13, of the Steam Engine Makers' Society, showed a total membership of 28,000 and a capital of 290,000*l*. The society had up to the above date expended in benefits 870,000*l*.

The report for October issued by the United Society of Boiler Makers and Iron and Steel Shipbuilders contains a statement by the general secretary, Mr. John Hill, to the effect that "we started our claim for the 44-hour week in May, 1918; we are now in the second winter, and a settlement by negotiations or as a result of inquiry seems as far off as ever. The employers in our industry have always fought shy of our inquiries into the economics of our industry. There is only one way of getting a real inquiry, and that is on the lines of the Sankey Commission. I am sure every member would be pleased to note that our Congress resolution on the 44 hours was carried unanimously. If the Parliamentary Committee takes up the mandate of Congress it will just give the additional impetus necessary to obtain the 44-hour week in the early months of next year." Last Tuesday a meeting on this question of reduction of working hours was held at the Central Hall, Westminster, between representatives of the employers' federation and of the unions. Considerable discussion took place, and the representatives of the unions stated at the close that they would refer the matter to their executives.

On the other hand, news comes from the International Labour Congress now being held at Washington to the effect that the workers' delegates presented their substitute draft for the 8-hour day or the 48-hour week. They urged the inclusion of commercial as well as industrial work, the 8-hour day as well as the 48-hour week, and the date for the convention to become effective to be July, 1920. They proposed, also, a special conference for seamen and agriculturists, to be called by the International Labour Office, and a recommendation to all Governments that the 48-hour week be adopted with the Saturday half-holiday. They opposed overtime, except in cases of emergency, or accident, with a maximum of 70 hours a year in seasonal industries at time and a half, as against 150 at time and a quarter proposed by the Organising Committee.

Sir Auckland Geddes, President of the Board of Trade, in the course of a speech he made last Saturday at the annual banquet of the Liverpool Shipbrokers' Benevolent Society, said ". . . it was easy to talk of slackness among workers, but too little, he thought, had been said of the other side: he knew from heart-to-heart talks up and down the country that the great manufacturers were not doing all they might to secure production in the works under their control, or to push the export trade. That was one of the first difficulties to be overcome, and if it was not overcome the export trade must inevitably lag . . ." Earlier in his speech he said that "one obstacle which stood in the way of increased exports was the fact that manufacturers said they were doing so well in the home markets that they need not bother about exports, because the home markets were soaking up all they could produce." We have not had "heart-to-heart talks up and down the country," but the information we do possess does not incriminate British manufacturers at all. The statements made by Sir Auckland Geddes are of such a sweeping nature that we hope to see them controverted by the British manufacturers themselves.

Addressing a meeting of railwaymen at Workington last Sunday, Mr. J. H. Thomas said: "I believe we shall be able to state before very long that we have evolved a scheme that not only enables all national and local grievances to be dealt with, but will give a real share in the control and management of the railways to the railwaymen's representatives, and establish a precedent that ought to do much to secure industrial peace, not only on the railways, but throughout the length and breadth of the land, in every industry in the country. But I do not want that to be confused or mixed up with our present negotiations. It would be idle for me to say that the proposals we are now considering on standardisation are such as, in my judgment, form the basis of a settlement. I do not think that they are acceptable—I know they are not acceptable—but we are still negotiating. We are still discussing the matter, and I sincerely hope that, as the result of our further negotiations and our further discussions, a settlement will be arrived at that will be satisfactory to the railwaymen." Mr. Thomas also said that the awards given to the engineering trades and the railway shopmen again demonstrated the vicious circle in which we were living. This would have the effect of further increasing the cost of living, and bring forth demands for more wages to meet this increased cost. A reduction in the cost of living was more necessary than increased wages. The workers, however, obviously could not be expected to agree to a reduction in their standard of living when they saw, notwithstanding the Profiteering Courts, profiteering still rampant. The latest returns concerning the railways showed that they were not in the bankrupt condition the public were led to suppose. He deduced from the latest White Paper that throughout the war no one benefited more from the railways and railwaymen than the great British public.

Sir Eric Geddes, the Minister of Transport, issued last week a Parliamentary Paper on the British Railways which shows that for the current financial year ending on March 31, 1920, the deficit on the working may exceed 45,000,000*l*., this deficit falling on the Exchequer.

Speaking in Parliament last Monday, Sir Rhys Williams, Parliamentary Secretary to the Ministry of Transport, stated that the number of women employed by the 14 principal British railway companies on November 11, 1918, was 55,797. On July 30, 1919, the latest date for which figures were available, the number had been reduced to 34,545. Most of the women still employed were only retained temporarily pending the return of the men who had left the service of the companies to join the Army and had not yet been demobilised, but who had been promised that the positions which they left should be kept open for them. The desirability of giving employment as far as possible to demobilised soldiers and sailors was fully realised.

The leaders of the American miners, after a lengthy meeting, decided early on Tuesday morning last to cancel the coal strike. Mr. Lewis, the president of the Union, stated that the miners would comply with the mandate of the United States Court, but would do so under protest, adding that they were American citizens and could not fight their own Government.

## THE DEFLECTION OF LIGHT BY THE SUN'S GRAVITATIONAL FIELD.

On the 6th inst., a joint meeting of the Royal Society and the Royal Astronomical Society was held, as a "meeting for discussion," the subject being the results of the observations obtained at the total solar eclipse on May 29, 1919. The opening paper was one by Sir F. W. Dyson, F.R.S., A. S. Eddington, F.M.S., and C. Davidson, entitled "A Determination of the Deflection of Light by the Sun's Gravitational Field, from Observations made at the Total Eclipse of the Sun, 1919, May 29." Of this paper the following is a brief summary:—

The paper gives the results obtained in the expeditions to observe the solar eclipse of May 29, sent out by the Joint Permanent Eclipse Committee. Two expeditions were sent out—one to Principe, on the West Coast of Africa, the observers being Professor Eddington and Mr. Cottingham; the second to Sobral, in North Brazil, the observers being Dr. Crommelin and Mr. Davidson. The observers at Principe had the astrographic object-glass of the Oxford University Observatory, which they used stopped-down to 8 in. as a fixed horizontal telescope, into which the field of stars surrounding the sun was reflected from a 16-in. cœlostat. Similarly, the observers at Sobral employed the astrographic object-glass of the Royal Observatory, also stopped down to 8 in., and, in addition, a 4-in. lens of 19-ft. focus, belonging to the Royal Irish Academy, supplied with light by an 8-in. cœlostat.

Owing to the exceptional number of bright stars in the neighbourhood of the sun, the conditions of this eclipse were specially favourable for the determination of a possible deflection of light, and the attention of the observers was concentrated on this special problem.

Happily both expeditions were successful. At Principe, in spite of cloudy weather, a few photographs were obtained, from which the deflection at the sun's limb was found to be 1·64″.

At Sobral a series of photographs with the astrographic object-glass, considered unsatisfactory on account of the distortion of the reflecting mirror, gave 0·93″ for the deflection at the sun's limb. A very good series of seven photographs, taken with the 4-in. object-glass, gave for the deflection 1·98″, with a probable error, judged from the accordance of the results of about 6 per cent.

The following table gives the deflections observed, compared with those predicted by Einstein's theory (which gives 1·75″ at the sun's limb):—

| No. of Star. | Displacement in R.A. | | Displacement in Dec. | |
|---|---|---|---|---|
| | Observed. | Calculated. | Observed. | Calculated. |
| | secs. | secs. | secs. | secs. |
| 11 | −0·19 | −0·22 | +0·16 | +0·02 |
| 5 | −0·29 | −0·31 | −0·46 | −0·43 |
| 4 | −0·11 | −0·10 | +0·83 | +0·74 |
| 3 | −0·20 | −0·12 | +1·00 | +0·87 |
| 6 | −0·10 | +0·04 | +0·57 | +0·40 |
| 10 | −0·08 | +0·09 | +0·35 | +0·32 |
| 2 | +0·95 | +0·85 | −0·27 | −0·09 |

It is concluded that the sun's gravitational field gives the deflection predicted by Einstein's generalised theory of relativity.

Glass Manufacture in Cuba.—A large glass plant for the manufacture of bottles, table and illuminating glass ware has recently been erected at Havana, Cuba. This is the first plant of its kind in Cuba, says the United States Bureau of Mines Report, and the outlook for its success seems promising. One of the factors most favourable to the establishment of the glass industry in Cuba is the supply of raw materials available on the island. This new company controls about 3,000 acres of glass sand, with an average content of 99·43 per cent. silica, and has ample resources of high grade limestone. Machinery and supplies are being purchased in the United States, and arrangements are being made for the importation of a number of experienced glass workers.

Personal.—We are informed by Mr. W. M. Mordey, of 82, Victoria-street, Westminster, that Major A. E. Levin, T.D., R.E.(T.), who was for some years associated with him and his late partner, Mr. R. A. Dawbarn, has now returned from overseas military service, and has joined him as partner. The firm will be known as Mordey and Levin.—Messrs. George Hatch, Limited (Machinery and Tools), announce that they have taken new offices at No. 3, Queenhithe, giving them largely increased accommodation both for their clerical staff and for warehouse.—Mr. F. Chambers, the foundry general manager of the Stanton Ironworks Company, Limited, is retiring from that position, and his place is being taken by Mr. P. H. Wilson. Mr. Chambers is retaining his seat on the Stanton Board, and will continue to act as consulting engineer to the company in connection with their foundry business.

## "CONTINUOUS BEAMS WITH END LOAD."

To the Editor of Engineering.

Sir,—From statements I have seen in various books and papers on the subject, it does not seem to be generally known that the "generalised theorem of three moments" for a continuous beam under lateral and end loading can be extended to include deflection of the points of support.

If the equation :

$$E\,I\,\frac{d^2y}{dx^2} = M$$

where M is the bending moment at any point $x$, is solved for each bay, the end conditions being used to find the constants of integration; and the slopes of the beam at the point of junction of two bays are found from the equation of each bay by differentiation, and are equated, the following formula finally results :—

$$\frac{w}{24}\left[\psi(\theta_1).l_1^3 + \psi(\theta_2).l_2^3\right] - \frac{1}{6}\left[f(\theta_1).M_A.l_1 + f(\theta_2).M_C.l_2\right] - \frac{1}{3}M_B\left[\phi(\theta_1).l_1 + \phi(\theta_2).l_2\right] - \left[\frac{1}{l_1} + \frac{1}{l_2}\right]E\,I\,\delta = 0.$$

where $\delta$ is the deflection of B, the intermediate point of support, from the line joining A and C, the two extreme points of support of the two bays under consideration :

$$\psi(\theta) = 3.\frac{\tan\theta - \theta}{\theta^3}.$$

$$f(\theta) = \tfrac{3}{4}.\frac{20\,\mathrm{cosec}\,2\theta - 1}{\theta^2}$$

$$\phi(\theta) = \tfrac{1}{4}.\frac{1 - 2\theta\cot 2\theta}{\theta^2}$$

and are sometimes referred to as "Berry functions."

In these functions $\theta = \frac{\alpha l}{2}$, where $\alpha = \sqrt{\frac{P}{EI}}$, where P is the compressive load in a bay. The remaining notation being as usual.

The only assumption, beyond those usual in the "Theory of simple bending," made in obtaining the above formula is that all the deflections are so small that $\left(\frac{\delta}{l}\right)^2$ can be neglected when compared with unity. In actual practice $\delta$ will seldom exceed 2 per cent., or at most 3 per cent. of the length of a bay, and so the above assumption holds good. On this assumption the formula given above can be shown to hold good for any number of bays.

I have not given the proof in full in this letter as it is somewhat lengthy and quite simple, but I shall be pleased to do so if you think the matter of sufficient interest.

Yours faithfully,

G. W. Higgs-Walker.

3, Russell-road, Hendon, N.W. 9,
October 23, 1919.

## THE ILLIMITABLE ATOM.

To the Editor of Engineering.

Sir,—I think it of considerable importance to call your attention to the fact that a letter from myself, published in your columns nearly ten years ago (March 11, 1910, page 311), under the heading "An Illimitable Atom," contains all the essential points of the new theory of the universe associated with the name of Einstein, as far as can be gathered from the published accounts.

The letter clearly puts forward the following points :—

1. That a so-called atom is probably a vibratory system without dimensional limits.

2. That all so-called atoms embrace and include all other atoms.

3. That light, radiant heat, &c., are actually outlying portions of the masses from which we have hitherto regarded them as emanating (and consequently just as much subject to the laws of gravity as the more central portions).

4. That the "distance" between one atom and another, or between one body and another, has no real meaning. The sunlight on the paper I am now using is actually part of the sun.

5. That if we had instruments of sufficient delicacy we could find traces of every element in the universe in a single cubic inch of stellar space.

6. That we never need worry any more about *actio in distans* or the absence of it. No such conception is required.

7. That the whole universe is one indivisible phenomenon and must be considered as such.

When I wrote that letter I was already on the look-out for proofs. I argued that if no atom was complete in itself, nor even its components, whatever they may be, the atomic weights, so indispensable in computing chemical combinations, would not represent the relative properties of the elements in any respect except in that one matter of the effect of gravity.

In other words, there must be some figure or quantity greater than the atomic weight which would be proportional to the mass of a so-called atom of that element, if such an atom could conceivably be entirely separated from all other matter, and the deficiencies in its vibratory system caused by such separation, made good.

The new figures would be as difficult to obtain experimentally as the absolute zero of temperature. Once found they prove their own utility and significance.

I have no doubt whatever that I have found such figures for the majority of the elements. They require no elaborate theories to support them, and do not run counter to any experimental data.

May I crave space for a simple mechanical analogy. A boy is given a piece of honeycomb and is told to find out how much a single complete cell weighs. He puts the lump of honeycomb into the scales and counts the number of cells; after doing a simple sum in division he says that each cell weighs so much. With greater knowledge and more observation he would realise that some of the material is functioning as a part of two or even three cells, and that the weight of the whole lump is not a simple multiple of the weight of a single complete cell, but something less. This *something less* is analagous to our atomic weights, and the reason for the difference is also analogous.

These numbers bear exceedingly simple relations to each other. They bear a much closer relation to the properties of the elements except in the matter of weight, and they lead almost conclusively to the decision that our atomic weights are comparatively simple fractions of each other (where correct), but not by any means the simple multiples of a basis element as suggested by Prout. Quite a number of our recognised atomic weights can only be expressed with absolute accuracy by the use of fractions or repeating decimals. For example, I can show that the combined atomic weights of cadmium and zinc should be eight-ninths that of mercury, that is to say, 177·7̇. On referring to a table of atomic weights we find that the combined atomic weights of cadmium and mercury amount to 177·77.

Silver would be more correct at 107·8̇, or 107$\frac{8}{9}$ instead of 107·88; antimony at 120·2̇, instead of 120·2, and so on.

These figures are by way of showing that my results are in accord with experimentally-proved facts within negligible limits, and they may, in fact, prove to be a useful check on atomic weights. Above all, they show that what we have hitherto called the atoms of the elements are interdependent, and that matter is continuous at any rate in the close proximity of the centres of vibration and activity. I find it difficult to conceive of any definite limit to this continuity.

Whilst others have searched for proofs in stellar space, I searched among accepted experimental data.

I received great encouragement from Professor Theodore Richards at Harvard, at the end of 1912, when the matter was in rather a crude stage. I have some interesting letters from him on the subject.

I soon afterwards offered to read a paper to the Institution of Civil Engineers, but the subject was not considered suitable. I requested them to file a copy of my notes as a record, and no doubt this has been done.

It has been exceedingly difficult to arouse any interest in this country. The magnitude of the subject has frightened most of the people with whom I have discussed it. May I pay you the compliment of saying that your journal and Harvard University are two of the very few exceptions.

Yours faithfully,

Frank W. Dodd, Assoc.Mem.I.C.E.

Birmingham, November 8, 1919.

## STANDARD SPINDLE NOSES FOR MILLING MACHINES.

To the Editor of Engineering.

Sir,—We have read with interest and carefully considered the arguments put forward in Mr. Vernon's letter in Engineering of November 7, and as the matter has now reached the stage of detail discussion, we believe that a statement of the reasons behind the type of spindle nose submitted by Messrs. Archdale, in your issue of October 24, becomes interesting.

In the first place we would state that the cylindrical form of spindle nose was only adopted after considerable discussion and actual tests by individual firms. The discussion dealt substantially with the points enumerated in Mr. Vernon's letter, and we would put them forward as follows :—

1. The design most suitable for a standard is the one which best meets modern heavy duties with large inserted blade cutters, due consideration being given to facility of adaptation to existing machines and cutters. Whilst admitting the desirability of patriotism in this respect, we cannot overlook the fact that in recent years certain American makers have developed high duty milling machines more quickly than has been done in this country, in fact, some of the heaviest cutting tests reported during recent years, have been on machines with spindle noses of the cylindrical type now under discussion.

2. At first glance it would appear that the taper cutter is more quickly applied and removed from the spindle, but we would point out that the slightest bruise or obstruction would cause the cutter to "run out," so as seriously to lengthen the time occupied in preparing for work. The cylindrical fit cutter may have a dummy shank tapped for the drawback bolt when the application of these cutters is exactly the same as that of the taper nose form.

The central bolt used with the taper-fit cutter, is also too long and elastic to keep the cutter firmly seated upon the taper, which latter being undesirably short would have an inclination to act as a spherical joint under heavy duties.

3. The threaded holes in the spindle are of such a depth that the wear upon them is found to be imperceptible, and being short and stiff, they hold the cutter definitely and rigidly to the spindle face, and give instant accuracy without any difficulty from cross-locking, which may possibly give trouble on the taper-nose form.

4. Whilst the loose keys may appear to be less substantial than the solid driving box, it should be pointed out that they drive the face mill at a much greater radius, and under heavy duty do not tend to injure the spindle as driving by the much smaller solid box. The accurate machining of these keys, and the necessary slot in the face mill, is also much simpler than the forming of the rectangular driving projection in the bottom of the taper recess of the face cutter.

5. Experience of several years with the parallel-fit type of spindle has shown that the cutters do not become objectionably slack in the cylindrical fit, and if they should do so, it is a much simpler matter to correct them by enlarging the recess and fitting a simple cylindrical ring, than it is to make a similar correction on the taper form, which would involve a delicate taper-turning operation, and possibly the provision of a taper sleeve and the deepening of the recess by milling round the driving projection.

6. We find no difficulty in applying the cutter to vertical spindle machines. The cutter is placed upon a packing block, 4 in. to 6 in. high, and after one screw is screwed home, the packing can be removed and remaining screws inserted, or the cutters may have a dummy shank tapped for drawback bolt, as mentioned in paragraph 2.

7. The question of the size of collars depends upon the duty of the machines. For ordinary milling practice collars of quite ordinary size can have driving slots to engage the inner ends of the keys, but for larger arbours, and those which are used for heavy milling, we consider the driving collar form to be preferable, as the arbour can then be made of a reasonable size of material, whilst the collar being a separate piece, can be made of very liberal diameter, by which the spindle nose transmits its drive without any injury to itself or the keys. An arbour, 1$\frac{1}{4}$ in. diameter, with a separate piece driving collar, 3$\frac{1}{2}$ in. diameter, has recently been twisted off without injury to the spindle.

Finally, it should be stated that the cylindrical form of spindle nose described by Mr. Archdale in Engineering of October 24, is already in use on large numbers of milling machines imported before and during the war, that these milling machines have been subjected to very heavy tests, which have confirmed the suitability of the spindle nose, and also that the four well known British firms of milling machine makers, mentioned by Mr. Archdale, are already supplying machines with this form of spindle nose.

Yours faithfully,

(For The Associated British Machine Tool Makers, Limited; Smith and Coventry, Limited),

p.p. I. H. Wright.

Manchester, November 10, 1919.

The late Mr. Martin Dessau.—We regret to have to announce the death, which occurred suddenly on the 6th inst., at his residence, "Eltham," Hellerup, Copenhagen, of Mr. Martin Dessau, late managing director of Messrs. Burmeister and Wain, Limited, shipbuilders and engineers, Copenhagen. Mr. Dessau was in his fifty-fifth year.

Reid's Colliery Guide.—We have received from Messrs. Andrew Reid and Co., Limited, of Newcastle-on-Tyne, a copy of the latest edition of Reid's Handy Colliery Guide for Northumberland, Durham and Yorkshire. This little book, which can easily be carried in the pocket, contains a map of the three counties, showing the positions of all collieries and railways, and also gives complete lists of colliery owners, collieries, agents, managers and engineers in these counties. Among other useful material included are a list of inspectors, reprints of various Acts and regulations relating to coal mines, and a collection of useful information, formulæ and statistics. The price of the book, bound in cloth, is 2*s.* 6*d.*

The British Industries Fair (Birmingham), 1920.—The Birmingham Section of the British Industries Fair has now secured buildings which will provide them with 150,000 sq. ft. of space for the housing of exhibits. The rapid and successful booking of space compelled the committee to make a drastic alteration in their original arrangements, and they are to be congratulated on obtaining the loan of the extremely suitable buildings which were erected during the war at the Castle Bromwich Aerodrome. The Air Ministry has consented to the buildings being used for the fair; this means that there need be no limitation of space, and exhibitors showing their products in two or more groups, will be able to have the same under their eye, as it were, without travelling to other locations, whilst buyers who have more than one interest will not be called upon to move from one district to another. The station (Castle Bromwich) is practically in the grounds, there being railway sidings for the exhibitors' special use. The Town Hall will be used as a reception bureau for all buyers visiting the fair, and there they will be able to obtain all the needed information as to hotel accommodation, transport services, places of interest, and the many other points on which strangers to the city will require assistance and advice. A special service of trains will be run on the Midland Railway from New-street Station, and, at regular and frequent intervals during the whole period of the fair, motor 'buses will leave the Town Hall for the aerodrome, and the aerodrome for the centre of the city. Letters should be addressed to the General Manager, British Industries Fair (Birmingham), Chamber of Commerce, Birmingham.

# 10-H.P. MOTOR CAR WITH FRICTION DRIVE AT THE OLYMPIA SHOW.

CONSTRUCTED BY MESSRS. PALLADIUM AUTO-CARS, LIMITED, PUTNEY, LONDON.

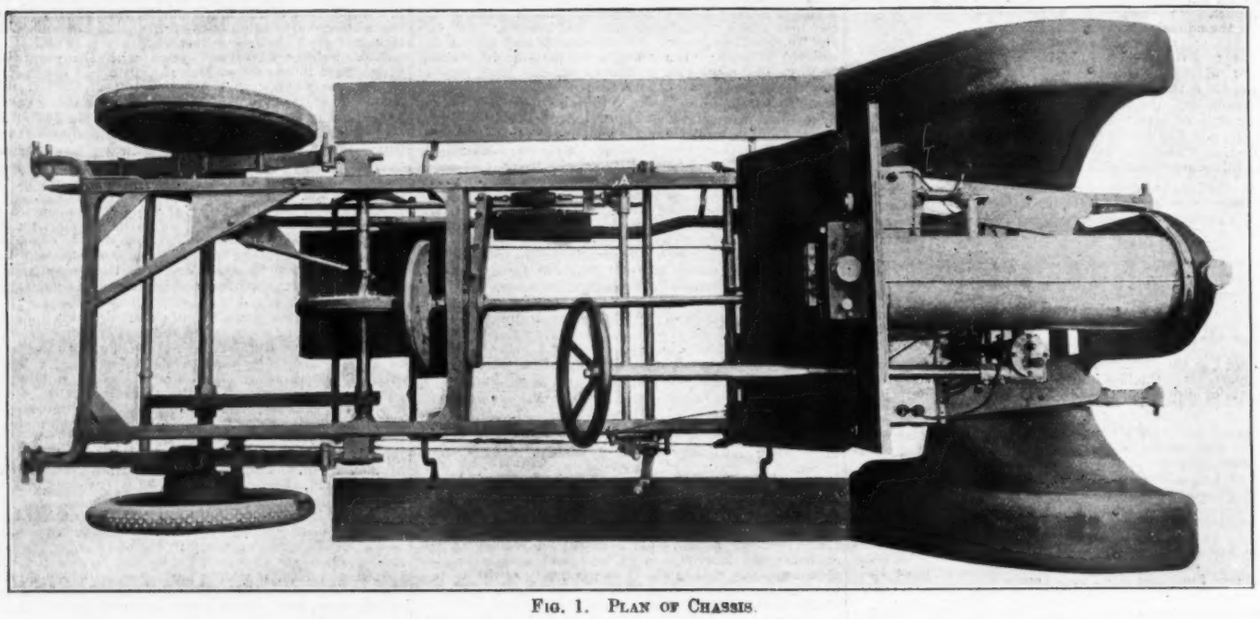
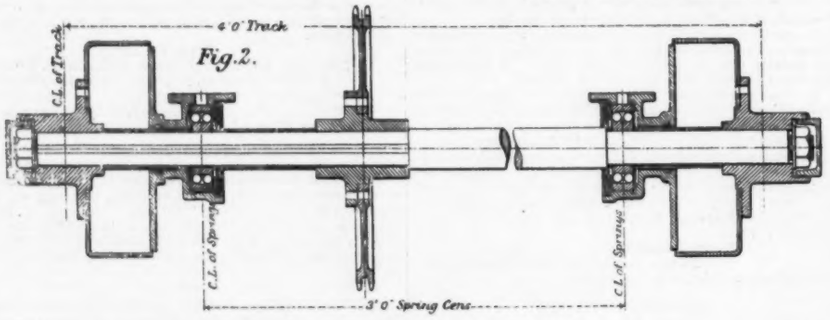
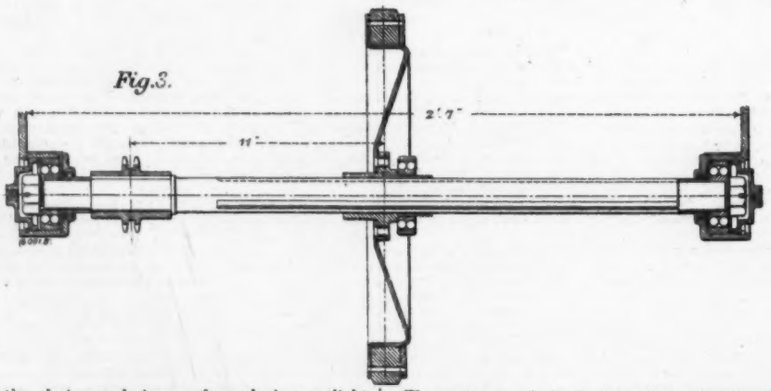
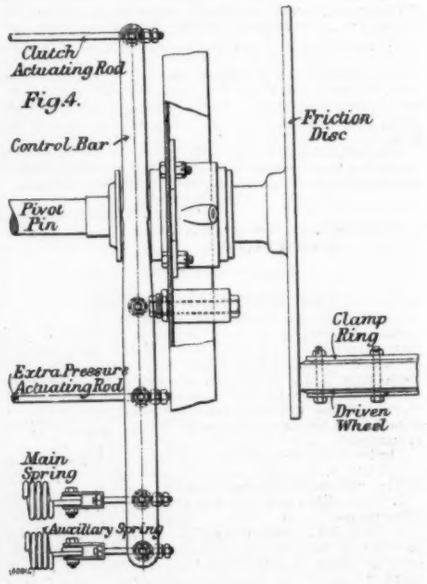


FIG. 1. PLAN OF CHASSIS.



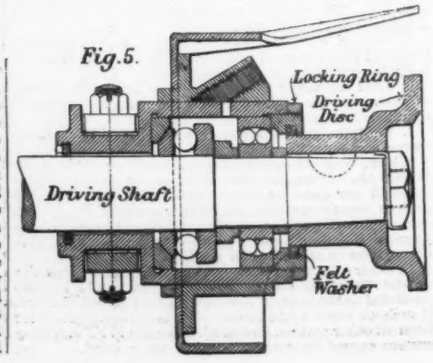




To the designer desirous of producing a light, inexpensive and efficient motor car, the friction drive must always have considerable attractions. The adoption of such a drive eliminates a large number of expensive and comparatively complicated parts, and at the same time materially reduces weight. A friction drive has been used with success for a number of years on a car which is to be seen at the Olympia exhibition, and one or two new makes on which the system has been adopted are also on view.

Of these latter we illustrate in Figs. 1 to 5 annexed the example shown by Messrs. Palladium Auto-cars, Limited, of Felsham Road, Putney, London, S.W.15. The car is fitted with a 10 h.p. engine, its wheel-base is 8 ft. 6 in. and the track 4 ft. The ground clearance is 7 in. and the weight 6 cwt. to 7 cwt. Either two or four-seater aluminium bodies can be fitted.

The engine is of the horizontally opposed cylinder type, the cylinders being 3½ in. in diam. by 4½ in. stroke. They are air-cooled by a patented induced draught system, being enclosed in a casing through which the fly-wheel draws air through louvres past fins on the cylinders. The cooling is thus proportional to the speed of the engine. The crankshaft is made from alloy steel, and the pistons are of aluminium and fitted with three rings. The camshaft is situated above the crankshaft and is driven by a silent chain running in an oil bath. The valves are on the top side of the cylinders. The magneto is driven off the end of the camshaft through a fabric joint. Lubrication is by drip-feed. Ignition is by high-tension magneto, and the carburetter is automatic with hand and foot control. The induction pipe is exhaust heated. A perforated screen is carried in front of the engine and



built into the body in such a way as to give the completed car the appearance of a water-cooled one. The cross member which hides the engine in Fig. 1 supports the front screen and the side panels, which normally enclose the engine.

Power is transmitted from the flywheel through a flexible fabric joint to the driving shaft, which carries the driving disc at its rear end. Immediately forward of the disc the shaft is supported in bearings carried by a cross member of the frame. This shaft carrying the disc can be clearly seen in Fig. 1, while Fig. 4 is an enlarged view of the end of the shaft and the disc. Fig. 5 is a section of the bearing on the cross-member of the frame. The disc drives a friction wheel which is set perpendicularly to it and runs on its rear face. The friction wheel is mounted on a cross-shaft which is carried on bearings on the side members of the frame. The friction wheel and its shaft can be clearly seen in Fig. 1, while it is shown in detail in Fig. 3. This shaft carries a sprocket and drives the back axle, shown in Fig. 2, through a chain. This drive can be seen in Fig. 1. The friction wheel carries a compressed cork rim which forms the friction drive on the disc, and speed change is of course obtained by moving the friction wheel across the face of the disc. The operating fork controlling this movement can be seen in Fig. 1, while the ball-bearing joint on which the fork operates is shown in Fig. 3. The control lever is arranged with five positions to give four forward speeds and reverse.

The arrangement by which the necessary pressure is obtained between the disc and the friction wheel can be seen in Figs. 1 and 4. The disc shaft carries a sleeve on which a pair of horizontal levers work in a groove. These levers, which are pivoted on the cross-member of the frame, as shown in Fig. 4, are caused to press the disc on to the friction wheel by a pair of helical springs. To release contact the pedal is pressed and pulls over the connecting link shown at the top of Fig. 4. This acts against the spring. In the case of slipping, or when for any other reason it is desired to increase the frictional grip, the pull of the spring can be reinforced by the second connecting link shown in Fig. 4. This connects to a second pedal and it will be clear that when it is pulled it assists the spring. The back axle, in Fig. 2, has no differential shown. Actually, what is done, is to fit a double cone clutch on the near side hub. When the car is turning this clutch slips and allows the non-positively driven wheel to run either faster or slower than the other.

The control of the friction drive, which we have described as simply as possible above, has a refinement which may now be mentioned. Of the two springs attached to the cross levers one is adjusted for tension permanently to suit the conditions of work. The other is automatically adjusted for tension with each change of gear. This is carried out by means of a cam which is situated at A in Fig. 1, the movement of the speed control gear causing the cam to extend or relax the second spring. Other details of the car will be followed from Fig. 1. Steering is by worm and sector, pressed steel disc wheels are fitted and the springing is semi-elliptical. Starting is by handle, but arrangements are made to fit a self-starter if required.

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THE INSTITUTION OF AUTOMOBILE ENGINEERS.—The London meetings of this Institution are to be held as follows: On December 3, January 7, 1920, February 4, March 4, April 7 and May 5. A meeting will be held in Birmingham on January 29, and a further meeting in March, the exact date of which is to be announced later. There is also to be a meeting in Coventry in May, and five meetings in Glasgow, before the Scottish Centre. Among the papers to be read may be mentioned the following: "Steels Suitable for the Various Parts of an Automobile, having in Mind the Standard Automobile Steels of the British Engineering Standards Association," by Dr. W. H. Hatfield; "The Practical Application of Electro-Deposition to Motor Vehicle Repair Work," by Major B. H. Thomas; "The Design of Motor Vehicles as Affected by War Conditions," by Lieutenant-Colonel T. B. Browne. Meetings of the Graduates Section are also announced to take place in London and Coventry; there will also be visits to works.

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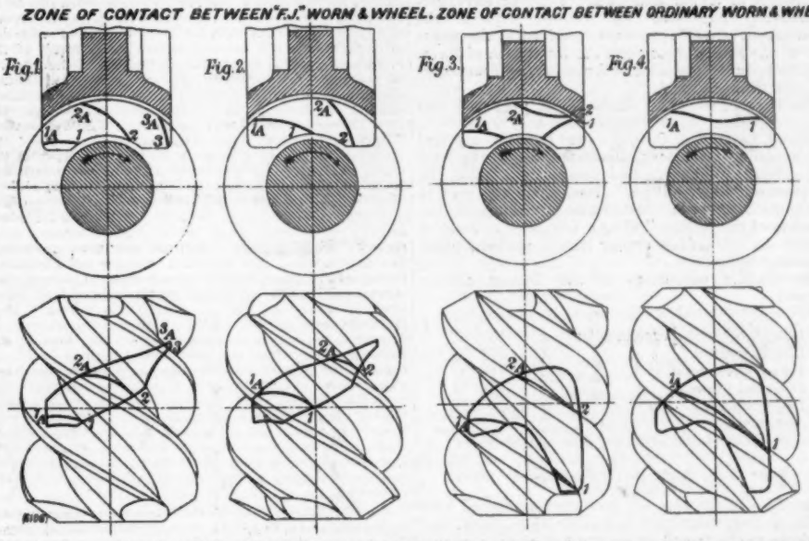
MACHINERY FOR WEAVING WOOLLEN FABRICS IN ITALY.—A description of a factory which has been recently established at Turin for producing machinery for the weaving of woollen fabrics recently appeared in the Italian press, says *The Board of Trade Journal*. It is stated that looms for weaving cotton used to be made in Italy, but that similar machinery for woollen fabrics came from abroad, partly from England, but principally from Germany. A few months ago the Dubosc factory was opened at Turin, and has now an output of about four looms a day, an output which is expected to increase. The quality is said to be excellent, and orders have been received not only from Italy, but also from France, Belgium and Brazil. Some difficulty has been experienced in obtaining raw material, but the iron castings which form the principal part of the looms are now supplied by the foundries in Piedmont. Foreign competition is not feared, since Germany is not at present in a position to produce or deliver this class of machinery, and in any case the Italian Government has been asked to protect this new industry.

## THE "F.J." WORM GEAR.

MESSRS. DAVID BROWN AND SONS (HUDDERSFIELD), LIMITED, of Park Works, Lockwood, Huddersfield, have recently perfected a new design of worm-gear, examples of which are exhibited on their stand at the Olympia Motor Car Show. It is known as the "F.J." gear, and we understand that the form of tooth used is the result of a mathematical research by the firm to determine the relationship between tooth contour and tooth contact. This investigation led to the conclusion that power transmission at absolutely uniform velocity could not be obtained by the "involute" form of tooth usually employed for worms, and it follows that the slight accelerations and retardations, although hardly detectable under ordinary working conditions, have a detrimental effect on the life and efficiency of worm gearing running at high speeds. These defects, it is claimed, are avoided with the new form of tooth, which not only gives a better contact between the teeth of the worm and worm wheel, but the contact is of a rolling nature which reduces wear and increases the efficiency of transmission.




In the accompanying illustrations, Figs. 1 and 2, are given sections and plans of a four-threaded worm and worm wheel with the new form of tooth. In the plan views the heavy lines show the calculated "zones of contact" between the teeth when the worm is rotated in a clockwise direction, as seen in the sectional views, and the intersections of the worm threads and the zone give the lines of contact between the worm and wheel teeth. These lines of contact are lettered 1A, 1, 2A, 2, and 3A, 3 in Fig. 1, and their positions, as seen in end elevation, are marked by similar lettering in the sectional-view. It will be noted that contact occurs on three tooth faces. In Fig. 2, the corresponding zone and lines of contact are shown after the worm has rotated through an angle of 45 deg., and it should be noted that the lines of contact, as shown in the sectional view, have all moved round in the direction of rotation of the worm. The line 3A, 3, is not shown, as contact now occurs on only two tooth faces. Similar zones and lines of contact for a worm of the ordinary (so-called "involute") form are given in Figs. 3 and 4, and here it will be noticed that contact occurs on two teeth only in the first position, and on one tooth only in the second position, *i.e.*, after a clockwise rotation of 45 deg. The lack of symmetry in the zones of contact, and the irregularity of the lines of contact with this form of tooth are clearly shown. It will be understood that, in both cases, during rotation of the four-threaded worm though an angle of 90 deg., the line of contact, 1A, 1, will sweep across the zone of contact into the position, 2A, 2, and in the case of the "F.J." tooth shown in Figs. 1 and 2, it should be noticed that the contact has travelled through an angle of about 60 deg. in the direction of rotation. Thus, about two-thirds of the motion is transmitted by rolling action and about one-third by sliding. In the case of the "involute" tooth form, however, the point of contact marked 1 in Fig. 3, has actually moved back to the position 2 in a direction opposite to that of the rotation, so that the rubbing velocity is rather higher than that due to rotation alone. The high rubbing velocity in the neighbourhood of the points 1 and 2, in Fig. 3, together with the convergence of the lines of contact, which indicates a concentration of load at this part of the tooth face, explains the well-known fact that, when a worm gear of the "involute" type is overloaded, pitting first takes place at the leaving side of the wheel.

Both worms and wheels are produced by an automatic generating process, and the former are made of mild steel, case-hardened, and finished by grinding. The worm wheels are made of a special high tensile phosphor bronze. A complete worm gear of the "F.J." type, with 6-in. centres and a gear ratio of 6:23 was recently tested in the Daimler-Lanchester worm gear-testing machine at the National Physical Laboratory. The worm and wheel had not been run together at all before being mounted in the gear case of the testing machine, and in one test an efficiency of 97·3 per cent. was obtained when transmitting 18·9 h.p. with the worm rotating at 1,500 r.p.m. The testing machine, it may be added, gives results accurate to within 0·1 per cent. Another interesting feature of these gears is the method of mounting the worm wheel in order to equalise the loads on the bearings of the worm-wheel shaft. For this purpose the worm-wheel is placed nearer to that bearing which takes the upward component of the side thrust. The components of end thrust and vertical load on this bearing will be increased by the decentralisation of the worm-wheel, but the load will be partially relieved by the upward component of the side thrust, and by suitably choosing the position of the wheel between the bearings, the load on both of the latter can be rendered practically equal. In every way these gears show great skill and forethought in design, as might be expected from the makers' long experience with this class of work.

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DISCUSSION ON LUBRICATION.—The meeting of the Physical Society of London, on November 28 (at 5 p.m., in the Imperial College of Science, South Kensington) is to be devoted to a discussion on the subject of "Lubrication." The physical qualities of a good lubricant have long eluded capture, and it is to be hoped that the discussion will throw light on the solution of the problem, and at the same time create a wider interest in the subject. Amongst those who will take part are the following: Mr. L. Archbutt, F.I.C.; Mr. R. Mountford Deeley; Mr. W. B. Hardy, secretary R.S.; Mr. F. W. Lanchester, M.Inst.C.E.; Mr. H. M. Martin; Principal Skinner; and Mr. T. E. Stanton, D.Sc., F.R.S. The meeting is open to all who are interested in the subject.

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ROADS AND TRANSPORT CONGRESS AND EXHIBITION (1919).—This Congress will be held at the Royal Agricultural Hall, Islington, London, N., from November 20 to 27, and the programme is the following: Thursday, November 20, at 3 p.m., official opening of the Congress and exhibition by the Right Hon. Sir Eric Geddes, G.B.E., K.C.B., M.P., Minister of Transport; Friday, November 21, at 11 a.m. and 2.30 p.m., conference on "Concrete roads, their construction, maintenance and life"; and on "Asphaltic macadam (bituminous) roads and their extended use"; Saturday, November 22, at 11 a.m., conference on "The consolidation and amendment of the Highways Law"; Monday, November 24, at 2.30 p.m., conference on "The relative advantages of single and double coat road surfacing work carried out in bitumen (as distinct from tar compounds)"; Tuesday, November 25, at 11 a.m., conference on "The conditions under which the heavier types of vehicles may use the roads, with special reference to their liability for extraordinary traffic damages"; Tuesday, November 25, at 2.30. p.m., conference on "The weight, construction and speed of mechanically-propelled vehicles in relation to the construction and maintenance of roads"; Wednesday, November 26, at 11 a.m. and 2.30 p.m., conference on "Provisions for and development of traffic in the future, with special reference to (*a*) provision of new roads, (*b*) road finance, and (*c*) provision of new transport services."

## H.M. LIGHT CRUISER "DRAGON."

THE evolution of the present type of light cruiser is perhaps as interesting in its way as that of her bigger sister, the battle-cruiser. The adoption of a type of machinery closely approximating to that hitherto used for destroyers has permitted the use of very high speeds, without sacrificing seagoing qualities or armament. The first of the present type of light cruiser was the famous "Arethusa" Class, so successful in the North Sea at the beginning of the war. These ships were followed by the "Calliope" Class and the "Ceres" Class, each representing an advance in size and armament, and further development was made in the "D" Class, ordered in 1917, of which the Dragon, illustrated on page 654, is an example. The displacement has been increased successively from 3,500 tons in the "Arethusa" Class to 4,720 tons in the "D" Class, and the length from 410 ft. to 445 ft.; while the radius of action and offensive power have proportionately increased. The various steps in the development of the type were described in the paper read at the annual meeting of the Institution of Naval Architects by Sir Eustace T. d'Eyncourt (see ENGINEERING, vol. cvii, page 482).

The Dragon, which we illustrate on page 654, was built by Messrs. Scotts' Shipbuilding and Engineering Company, Limited, at Greenock, and they also supplied the propelling machinery, illustrated also in the same page. Scotts' Company had previously engined the Conquest, of the "Calliope" Class, which was built at Chatham Dockyard; had built and engined the Caradoc, of the "Ceres" Class; and have in hand at present the "D" Class cruiser H.M.S. Durban, which is nearing completion.

The leading particulars of the Dragon are as follows:—

| | Ft. In. |
|---|---|
| Length between perpendiculars .... | 445 0 |
| Length overall .... .... .... | 471 0 |
| Breadth (extreme) .... .... .... | 46 0 |
| Designed draught .... .... .... | 14 3 |
| Displacement .... .... .... | 4,720 tons. |

Armament—

Six 6-in. guns and two 3-in. (high angle) guns.

Four 21-in. triple revolving torpedo tubes.

The sides of the ship are protected by special high tensile plating, varying from 3 in. to 1½ in. thick, and the decks are protected by plating 1 in. thick. As can be seen from the engraving, Fig. 1, provision is made for carrying a scouting aeroplane under the bridge, immediately aft of the second 6-in. gun.

The propelling engines consist of Brown-Curtis geared turbines driving twin screws (Fig. 2). Steam is supplied at 235 lb. per square inch by six water-tube boilers of Yarrow type; two in the forward stokehold, and four in the after stokehold. The propelling engines are arranged in two engine rooms, one forward of the other; that in the forward engine-room driving the starboard shaft, and that in the after engine-room the port shaft. This arrangement is necessitated by the large power involved, and the consequent space athwartship occupied by the turbines and gearing. The main gear wheel on each propeller shaft is driven by two pinions, one actuated by the high-pressure turbine and the other by the low-pressure turbine, the latter having combined in its casing an astern element. Arranged in tandem with the high-pressure turbine, and in series with it, is a cruising turbine. This turbine, which may be connected by means of a clutch to the high-pressure rotor, is used when the total shaft horse-power does not exceed 6,000, corresponding to a speed of about 18 knots.

The trials of the ship were carried out on the Firth of Clyde, and were highly satisfactory in all respects. A shaft horse-power of 40,000 was obtained, corresponding to a speed of 29 knots, and the boilers easily supplied the steam required throughout the 4 hours full-power trial. On the progressive speed trial a shaft horse-power of 41,960 was recorded with the propellers running at 270 r.p.m. The steam pressure at the high-pressure turbine nozzles was 206 lb. per square inch, and the vacuum in the condensers was 28¼ in.

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THE LIBRARY OF THE CHEMICAL SOCIETY.—A pamphlet by Mr. F. W. Clifford, reprinted from "The Library Association Record," has been recently issued, dealing with the scheme carried out for the last two years by the Chemical Society for extending that society's library. The following societies have co-operated in the extension, giving financial support to the scheme, and their members now have full use of the library, both for loan and reference: Association of British Chemical Manufacturers; Biochemical Society; Faraday Society; Institute of Chemistry; Society of Chemical Industry; Society of Dyers and Colourists; Society of Public Analysts. The library is now open daily from 10 a.m. to 9 p.m., with the exception of Saturdays, when it is closed at 5 p.m.

## NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

*Iron and Steel.*—Serious effects are threatened in the engineering trade this week if the moulders' strike remains unsettled. Some of the leading steel producers are on the point of exhausting their emergency stocks of moulds, and several of the largest machine shops can no longer carry on without fresh supplies of castings. A big expansion of unemployment is immediately threatened. Engineering employers by co-operation have held off the worst effects of the strike until the last possible moment, but will now be compelled to dispense with the services of a large number of men in dependent branches. The number of men on the books of the Sheffield Labour Exchange drawing unemployment pay is no indication of the extent of unemployment. Several thousands of men who were engaged in machine shops and other departments since shut down as a direct result of the moulders' dispute, are drawing upon their union funds. The unions in question, who are feeling the pinch severely, have made a further unsuccessful application to the Ministry of Labour for out-of-work pay to be extended to these workers. In regard to railway transport, the position is rather worse than better. Production in departments not directly affected as a result of the moulders' strike is being held up because of the scarcity of wagons. Consequently manufacturers are taking special interest in the progress of Sheffield Corporation's scheme to develop waterway-transport between the Don Valley and the East Coast ports. The corporation propose to improve canal facilities so as to allow the introduction of motor barges of 300 tons capacity in the place of the present horse-drawn boats, to furnish up-to-date wharf facilities, and, if possible, to run sidings direct from the canal to the big iron and steel works. The improvement in overseas trade is reflected in increased activity in crucible steel production. Furnaces until recently working only half-time are now producing five days a week, and there is a stronger call for manufactured and partly manufactured steel. Overseas consumption of special steels and particularly of high-speed steel, is slowly expanding. America is taking a considerable tonnage of Sheffield's high-speed steel output. American buyers are anxious to secure deliveries at the current rates before the proposed American tariff on tungsten products is put into effect. Wire drawers have a big volume of work on hand. To meet this new plant has been introduced, which has increased the local output beyond any comparable magnitude. The moulders' strike fortunately has not extended to the light castings trade. Foundries supplying builders' requirements and other light castings are working at high pressure, and could employ much more skilled labour if it were available.

*South Yorkshire Coal Trade.*—London's exceptionally strong demand is causing a shortage in provincial towns. The scarcity of railway wagons is unrelieved. Collieries are striving to maintain their record for improved output, but at intervals are compelled to suspend production where stocking facilities are restricted. Merchants in the Sheffield district declare that wagons are carrying only about half their usual tonnage. All qualities of steam fuels occupy a very strong position. House coal continues in active demand. Country districts are pressing for increased supplies for threshing and ploughing work. Cokes of all classes are difficult to obtain. Quotations:—Best branch handpicked, 33*s.* to 34*s.*; Barnsley best Silkstone, 33*s.* to 33*s.* 6*d.*; Derbyshire best brights, 31*s.* to 32*s.*; Derbyshire house coal, 28*s.* 6*d.* to 29*s.*; Derbyshire best large nuts, 28*s.* 6*d.* to 29*s.* 6*d.*; Derbyshire small nuts, 27*s.* 6*d.* to 28*s.* 6*d.*; Yorkshire hards, 28*s.* 6*d.* to 29*s.* 6*d.*; Derbyshire hards, 28*s.* 6*d.* to 29*s.* 6*d.*; best slacks, 24*s.* to 25*s.*; nutty, 23*s.* to 24*s.*; smalls, 19*s.* to 20*s.*

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STANDARD SYSTEM OF LIMIT GAUGING.—It is now widely known that the British Engineering Standards Association has had under consideration for some time past the question of a standard system of limit gauging for plain cylindrical work applicable to engineering generally. The Sub-Committee on Limit Gauges, recently reorganised as a result of a trade conference held in April last, has decided to recommend the adoption of the hole basis, and is hoping to settle shortly the important question of the disposition of the tolerances with regard to the nominal dimension. Two methods have been proposed: (1) That the mean dimension of the hole should be its nominal size, the tolerance being both positive and negative; (2) that the minimum dimension of the hole should be the nominal size, the whole tolerance being positive. From inquiries which have been addressed to a number of engineering firms throughout the country it appears that opinion is divided as to which method should be adopted. It is realised that the matter is of vital importance to the industry as a whole, and involves large issue to individual firms. The association is, therefore, most anxious that it should have as wide a publicity as possible in order that whatever decision is arrived at it shall, in so far as may be possible, express the wishes of the industry of the country, and be suitable not only to a few works but provide a large measure of national interchangeability. To ensure that all may have an opportunity of presenting their views, the association wishes to enlist the co-operation of the technical Press in putting the matter before the engineering industry. The question, it is hoped, may be finally discussed in a few weeks time by the sub-committee, and any firm desirous of obtaining further information, or of giving its views, is invited to communicate at once with the Secretary of the British Engineering Standards Association, 28, Victoria-street, Westminster, S.W. 1.

## NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

*The Cleveland Iron Trade.*—The Cleveland iron trade shows no new movement of moment. Foundry quality is still very scarce, but the shortage is not quite so acute as it has been. Some makers, however, are refusing to entertain offers of new business. Distribution continues to be most seriously hampered by the truck shortage, which is as pronounced as ever. Forge pig-iron, though quite abundant, fully maintains its value. Scottish consumers of Cleveland iron are rather keen to buy, and though they prefer foundry kind, when they fail to obtain that description, they are purchasing forge pig-iron. For home consumption, No. 1 Cleveland pig-iron is 164*s.*, No. 3 g.m.b. and No. 4 foundry are each 160*s.*, and No. 4 forge ranges from 157*s.* to 160*s.*, according to brand. Export prices are 5*s.* above these rates.

*Hematite Iron.*—Supply of East Coast hematite is plentiful. Home demand is not heavy just now, but foreign inquiry keeps good, and further substantial Continental sales are looked for. Nos. 1, 2 and 3 are 200*s.* for home use and 205*s.* for export, and No. 1 is 202*s.* 6*d.* for home purposes, and 207*s.* 6*d.* for shipment abroad.

*Iron Imported from Antwerp.*—The arrival here of a cargo of Luxembourg basic iron from Antwerp has caused some stir, but little serious attention is paid to the circumstance which is not expected to be repeated to any extent. A curious chance is the fact that the vessel which brought in the iron will make a return voyage to Antwerp with a cargo of Cleveland pig-iron.

*Foreign Ore.*—There seems little hope of revival of activity in foreign ore. Consumers are very well placed, and are not in the market to buy, whilst as sellers are considerably in arrears with deliveries they are not at all anxious to enter into new contracts. Quite a number of ore steamers are lying here, and complaint of delay in discharging is most pronounced. Rubio, of 50 per cent. quality is put at 52*s.* 6*d.* c.i.f. Tees, and the freight Bilbao-Middlesbrough is round about 24*s.* 6*d.*

*Coke.*—Coke continues scarce. Local demand shows no abatement and, indeed, consumers complain of difficulty experienced in obtaining adequate quantities for the blast furnaces. Fixed maximum rates are readily realised. Average furnace quality commands 48*s.* at the ovens, and low phosphorus sort makes 49*s.* 6*d.* at the ovens.

*Manufactured Iron and Steel.*—The accounts given of the manufactured iron and steel industries must be regarded as rather satisfactory. Substantial home and foreign inquiries are still in the market, but most firms are understood to be so busily employed that they are unable to quote for anything like early delivery. Values of all descriptions are well maintained. Export prices are not fixed, but may be given as a little above the following quotations, which govern home business:—Common iron bars, 22*l.*; marked bars, 25*l.*; strip iron, 23*l.* 5*s.*; black sheets, 26*l.*; galvanised sheets, 35*l.* to 36*l.*; steel ship, bridge and tank plates, 18*l.* 5*s.*; steel boiler plates, 21*l.* 10*s.*; steel angles, 17*l.* 15*s.*; steel joists, 17*l.* 10*s.*; and heavy steel rails, 16*l.* 10*s.*

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THE LATE MR. MEPHAN FERGUSON.—We regret to have to announce the death, which occurred at Melbourne, last Sunday, the 2nd inst., of Mr. Mephan Ferguson, the founder of the firm Mephan Ferguson Proprietary, Limited, engineers and Government contractors, Melbourne, Perth and Adelaide, Australia, and the inventor of the Mephan Ferguson lock-bar pipe.

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THE GEOLOGICAL SURVEY, AND MUSEUM OF PRACTICAL GEOLOGY.—The Geological Survey of Great Britain and Museum of Practical Geology, Jermyn-street, S.W., have been transferred for administrative purposes from the Board of Education to the Department of Scientific and Industrial Research, as from the 1st inst. Correspondence with reference to the work of the Survey should be addressed as heretofore to the Director of the Survey and Museum, Jermyn-street, S.W.

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DIVING MANUAL.—Although this manual is published by Messrs. Siebe, Gorman and Co., Limited, of 187, Westminster Bridge-road, London, S.E., and refers largely to the productions of that firm, it cannot by any means be regarded as a catalogue. Its main object is to ensure the safety of divers and caisson sinkers working at great depths, but much of the information given will be extremely valuable to submarine workers engaged in harbour, dock and bridge construction operations in shallower water. The manual explains the latest practice adopted for diving operations in the British Navy, which practice has been largely founded on the research work of Professor J. S. Haldane, M.D., F.R.S., Professor Leonard Hill, M.B., F.R.S., and other experts, among whom must be included the firm of Siebe, Gorman and Co. After describing the construction and working of different forms of diving apparatus, the manual deals very fully with the physics and physiology of diving, and also illustrates and describes a great variety of accessory apparatus for submarine work. Numerous examples of civil engineering work, marine salvage and other operations involving the use of dress divers, or diving bells, are illustrated and described in an interesting manner, and chapters on submarine mines, moorings, &c., are also included. The book, which has been compiled by Mr. R. H. Davis, concludes with a chapter on the history of diving, and illustrates a number of extremely interesting relics recovered from sunken vessels by Messrs. Siebe, Gorman's divers. It is bound in dark red cloth and is sold at the price of 7*s.* 6*d.*

## NOTES FROM THE NORTH

GLASGOW, Wednesday.

*Steelworks Bricklayers' Strike.*—The strike of the bricklayers employed in the Scotch steel works, which has now lasted for seven weeks, still continues, but there are signs that the two parties may soon come to an arrangement by which an early resumption of work is highly probable. The dispute has reached the point that the men are prepared to return to work, and to remove the embargo on overtime, provided the employers will meet their representatives within a week thereafter to discuss any question which the latter may desire to bring forward. In the event of a failure to reach an agreement upon any of the points submitted for discussion the employers are willing to refer these points to immediate arbitration. Should an advance in wages be granted, such advance will date from the time of resuming work. The one point which may be the most difficult to settle is in connection with overtime, but considering that the strike has already lasted so long it is not likely that even that question will be a stumbling block to complete agreement.

*Scotch Steel Trade.*—The dislocation in the Scotch steel trade caused by the dispute with the bricklayers has now become rather serious, and many workers have been thrown out of employment. Supplies of plates to shipbuilders and boilermakers are down to the very minimum with the result that much urgent work is being seriously affected. Any plates available are eagerly snapped up and go quickly into consumption. The general export trade is on a small scale, but there are still many inquiries on the market. Black sheet makers continue very busy, and last week prices were advanced by 20*s.* per ton. The home quotations are now 24*l.* 10*s.* per ton f.o.t. Glasgow for sheets ¼ in. to ¼ in. thick. Gauges, 12-13 are 2*s.* 6*d.* per ton more; 14-16 gauges are 25*l.* 5*s.* Thin sheets, 25-27 gauge, are now 28*l.* Export prices are also correspondingly firmer. For galvanised sheets there is a good business passing even at the present high level of prices.

*Malleable Iron Trade.*—There has been no change in the state of the malleable iron trade of the West of Scotland during the past week, and much activity still prevails at the various works. The business on hand amounts to a very large tonnage, and home consumers are very pressing in their demands for supplies. Provided that no further labour troubles should arise to dislocate things a good steady run is assured. Export orders are at present receiving little attention owing to the home requirements, and some favourable contracts have been directed elsewhere. Prices are firm and unchanged.

*Scotch Pig-Iron Trades.*—The Scotch pig-iron trade exhibits a fairly healthy tone this week and quite a respectable business has gone through chiefly on home account. There are rather more export orders on offer, but a slight shortage of material prevents the desired expansion. The higher grades are not over plentiful yet but a fairly good supply of forge and foundry iron is available. Quotations show no alteration.

*Scotch Coal Trade.*—There is quite a good demand for Scotch coal at the present time, and deliveries are improving. Drosses are rather a glut in the market, which is largely due to the trouble in the steel trade as very small supplies are going into consumption there.

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ALUMINIUM IN NORWAY.—Norway is not well provided with aluminium minerals. There is practically no bauxite, and kaolin and clays rich in alumina, like those of Sweden and the Continent, which have been utilised in aluminium works with more or less success, are rare; the Norwegian clays do not contain more than 20 per cent. of alumina, whilst Hungarian and Bavarian clay are said to come up to 30 per cent. There is a potash, feldspar with 16 per cent. of alumina, but little has been done with it. Lecturing recently before the Institution of Engineers in Kristiania, V. M. Goldschmidt stated that the Norsk Elektrochemist Company was trying labradorite from the Western provinces of the country containing 30 per cent. of alumina. Labradorites are feldspars, silicates of aluminium, sodium and calcium. The works are at Lysaker and the Norsk Hydro Company, which makes nitric acid, are interested in the scheme.

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WATT CENTENARY EXHIBITION.—Numerous objects, illustrating the inventions of James Watt, as well as his methods of experimental work, have been gathered from different sections of the Science Museum, South Kensington, and grouped in the Central Hall (Room 3), where they will remain for a few months to constitute a Watt Centenary Exhibition. Illustration of the leading developments in the steam engine during the century which has elapsed since the death of Watt, have been grouped in the adjoining gallery (Room 2). The interest of the exhibition has been greatly augmented by the fact that valuable loans from other Institutions and private sources have been temporarily added to the rich collection of relics permanently housed in the museum. A catalogue of the exhibition, which has just been issued by the Board of Education, gives some particulars of over 300 items including pictures, and stationary steam pumping engines and accessories, rotative steam engines, and other inventions of Watt, as well as holograph letters from Watt and biographies and other contributions relating to the great engineer. The catalogue is obtainable through any bookseller, or directly, from H.M. Stationery Office, Imperial House, Kingsway, London, W.C. 2, or from Messrs. E. Ponsonby, Limited, 116, Grafton-street, Dublin; its price is 1*s.* net.

## NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

*The Local Coal Market.*—There is no change in the general condition of the coal market. Collieries are still insufficiently supplied with wagons to keep working regularly, and stocks are more than enough to meet current demands, which are restricted by a lack of shipping and slow loading operations at the docks. The latter factor is to a large extent responsible in the shortage of railway facilities and delays in the return of empty wagons to the pits. It is safe to say that on the average it takes the tippers at present twice as long to load vessels as it did before the coming into operation of a minimum wage for tippers in April, and the introduction of pooling work by the trimmers early in August. The trade is feeling the effects of this slow working. At the same time outputs of late have been increasing and, as the available supply of wagons for inland consumption is also restricted, temporary stoppages at the pits are inevitable. For quick loading prices are on the basis of 70*s.* for the best quality large steam coals and 52*s.* 6*d.* for best steam smalls with other qualities in proportion. Buyers able to take spot delivery can, in fact, secure supplies at 2*s.* 6*d.* to 5*s.* under these figures. Of late a good deal of interest has been taken in contract business over next year and, though transactions are nothing like those in normal times, a fair amount of business has been concluded chiefly for French railways. The Paris, Lyons and Mediterranean Railway is reported to have contracted for 250,000 tons delivery over the whole of next year on the basis of 70*s.* per ton f.o.b. for second-class Admiralty large coals, while business has also been concluded for the best class large over next year at 72*s.* 6*d.* and 75*s.* f.o.b. and for the better quality steam smalls at 50*s.* to 55*s.* f.o.b. Exports of coal from South Wales last week totalled 357,892 tons, of which 243,093 tons, equal to 68 per cent. of the total, went to France, 40,283 tons to Italy, 13,819 tons to South America, 3,795 tons to Spain, 965 tons to Portugal, 38,559 tons to British coaling depots, and 17,378 tons to "other countries."

*The Iron and Steel Trades.*—The feature of this market is the continued upward tendency of tinplate prices. A shortage of bars and restricted output, as a result of insufficient water to keep works fully employed, checks production, and the demand is more than sufficient to absorb available supplies. In fact, some makers are full up with orders till the middle of next year, and there is keen competition to secure the isolated parcels available for quick delivery. Prices have reached a new record of 45*s.* 6*d.* f.o.b. per standard box. Makers are behind in their deliveries under contract and in isolated instances plates, which should have been delivered last month, have not yet been rolled. The home and foreign demand is particularly pressing and active. Galvanised sheet prices are 5*s.* higher than a week ago, and 24-gauge corrugated in bundles now commands 35*l.* 10*s.*, with other qualities ranging from 46*l.* to 51*l.* Tin and sheet bars are firm at 15*l.* per ton. Shipments of tinplates from Swansea last week totalled 84,032 boxes, receipts from works at docks 87,052 boxes, and stocks in dock warehouses, &c., 212,087 boxes.

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JAPANESE CENTRAL STATION.—Two 25,000-kw. steam-driven turbine units of Westinghouse make, which when installed will complete the largest steam-driven electrical installation in the Far East, are now being erected at Osaka, Japan, for the Osaka Electric Light Company. Located in an extensive industrial district, this company furnishes light and power to street railways, steel works, shipbuilders, copper-refining plants, paper mills, electro-chemical installations and other industries. It is noteworthy that in 1908 the Osaka Company installed three steam turbine units of 3,000 kw. each. In 1910 two more units of like capacity were added, and in 1911 two 5,000-kw. units. All of the above units are of Westinghouse manufacture.

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TESTS OF MARBLES.—In conjunction with the United States Geological Survey, the Bureau of Mines and the Bureau of Public Roads, the United States Bureau of Standards is investigating the properties of the building stones of the country. The first report published, Technical Paper No. 123, a pamphlet of 54 pages, illustrated by 7 plates, deals with 52 types of marbles, and is drawn up by D. W. Kessler. The tests comprise strength, porosity, density, water absorption, expansion, weathering, and electric and chemical properties. The compressive strengths are determined in the original dry condition, and after soaking the specimens in water for two weeks; this soaking generally reduces the strength, sometimes by more than 25 per cent.; the compressive strength values ranged from 7,850 lb. to 50,205 lb. per square inch. The tensile and breaking strengths, parallel and transverse to the bedding plane, are also determined. The series of 30 freezing and thawing tests generally diminished the strength considerably; in some cases, however, no loss of strength was observed, and a special apparatus has hence been designed, in which the specimen is shifted to and fro between a cold chamber and a warm chamber more than 30 times. As regards the electric resistance, various dry and moist marbles differed greatly, so that a careful selection should be made of marbles for switchboards, &c. The thermal expansion tests gave irregular results. Marble does not seem to expand regularly even at ordinary temperature, and the rate of expansion increases with rising temperature, so a simple expansion coefficient cannot be given; on cooling the marble does not contract to its original dimensions, moreover, each repeated heating adding a slight increment. Some cases of warped marble slabs were also examined.

## NOTICES OF MEETINGS.

THE INSTITUTION OF CIVIL ENGINEERS.—Tuesday, November 18, at 5.30 p.m. Paper to be submitted for discussion, "Admiralty Harbour, Dover," by Mr. Maurice Fitzgerald Wilson, M.Inst.C.E.

THE INSTITUTION OF PETROLEUM TECHNOLOGISTS.—Tuesday, November 18, at 5.30 p.m., at the House of the Royal Society of Arts, John-street, Adelphi, W.C. 2. The following paper will be read, "The Conservation of Oil," by Rear-Admiral (Retired) Philip Dumas, C.B. The chair will be taken by the president, Sir Frederick W. G. Black, K.C.B.

THE ROYAL SOCIETY OF ARTS.—Wednesday, November 19, the Opening Address of the 166th Session, on "Science and Industry," will be delivered by Sir Henry Trueman Wood, M.A., vice-president and chairman of the Council. The chair will be taken at 4.30 p.m.

THE INSTITUTION OF ELECTRICAL ENGINEERS.—Wednesday, November 19, at 6 p.m., at the Institution of Civil Engineers, Great George-street, Westminster, S.W., when Professor C. L. Fortescue will read a paper on "The Design of Multiple-Stage Amplifiers, Using Three-Electrode Thermionic Valves."

THE LIVERPOOL ENGINEERING SOCIETY.—Wednesday, November 19, at 8 p.m., the second ordinary meeting at the Royal Institution, Colquitt-street, when a paper will be read by Mr. H. B. Ward, M.C., M.Sc. (Vict.), M.Eng. (L'pool), Assoc.M.Inst.C.E., F.S.I., entitled "Progress in Sewage Disposal."

THE INSTITUTION OF MINING AND METALLURGY.—Thursday, November 20, at 5.30 p.m., at the Rooms of the Geological Society, Burlington House, Piccadilly, London, W. 1, the following paper will be submitted for discussion, "A Contribution to the Study of Flotation," by Mr. H. Livingstone Sulman, Member.

THE INSTITUTION OF MECHANICAL ENGINEERS.—Friday, November 21, at 6 p.m., at the Institution, Storey's Gate, St. James's Park, S.W. "The Present Position of Mechanical Road Traction," by Mr. C. G. Conradi, of Derby, Member.

THE JUNIOR INSTITUTION OF ENGINEERS.—Friday, November 21, at 7 p.m., at the Royal Society of Arts, John-street, Adelphi, W.C. Annual general meeting. Paper, "The Limitation of Electric Tramways," by Mr. W. A. Tookey, M.I.Mech.E. (past chairman).

THE SOCIETY OF TECHNICAL ENGINEERS: BIRMINGHAM BRANCH.—Friday, November 21, at 7 p. m., at the Chamber of Commerce, New-street, Birmingham, when Mr. W. A. Twine, A.I.C., A.M.I.M.E., will give a lantern lecture on "Chemical Engineering Up-to-date."

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AGRICULTURAL AND GENERAL ENGINEERS, LIMITED.—With reference to the recent issue of 840,000 8 per cent. cumulative preference shares of £1 each at par, it is reported that the issue has been fully subscribed, and the list was closed on Thursday, the 6th inst.

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THE LATE MR. JOHN HENRY DARBY.—We regret to have to record the death, which occurred on October 26, of Mr. John Henry Darby, who was for many years a Member of Council of the Iron and Steel Institute, also a member of the Institution of Civil Engineers, the Cleveland Institute of Engineers, the American Society of Mechanical Engineers, and other bodies. Mr. Darby was one of the pioneers of the basic open-hearth steel process, and of the by-product coke-oven process in this country, and for his work in regard to the former he was awarded the Bessemer medal in the gift of the Iron and Steel Institute in the year 1912. Mr. Darby received his training at the Brymbo Ironworks and Collieries, North Wales. For several years he was manager of the Broughton, Plas Power, and Brymbo collieries, near Wrexham, but most of his life was spent in the management and direction of the Brymbo Iron and Steel Works. He was a gifted metallurgist and chemist, with a quick grasp of the practical application of ideas. In 1884 he introduced at the Brymbo works the then new basic open-hearth process of steel-making referred to above; the process has been ever since successfully carried out at Brymbo. He was the inventor of a method of re-carbonising steel without spiegel or ferro-manganese, a process which was largely used for many years in the manufacture of rails and sections. He was also one of the first to use a basic-lined gas-heated metal mixer. In 1893 he installed a by-product coking plant (Semet-Solvay system) at the Brymbo works, this being the first of its kind to be worked in conjunction with iron and steel works in this country. Later, he founded the coke-oven business now registered as "The Coke Oven Construction Company, Limited," and was responsible for the design and erection of a large number of Semet-Solvay plants throughout Great Britain. Amongst the improvements introduced by him were the automatic coke-quenching hood, known by his name, and he was the first in this country successfully to carry out the mechanical stamping and charging of coal for by-product coke ovens. He was deeply interested in ironstone deposits, and reported on many of these in different parts of the world, and he designed large iron works to smelt the Australian ores, a scheme which will no doubt mature at a later date. He did much towards the development of the ironstone of Oxfordshire, and in Lincolnshire, acting for Messrs. John Lysaght, Limited, he undertook in 1908 the design and erection of a new plant, including by-product coke ovens, blast furnaces, steel works and rolling mills, at Normanby Park, near Scunthorpe. Mr. Darby was 63 years of age.

# H.M. LIGHT CRUISER "DRAGON."

CONSTRUCTED BY MESSRS. SCOTTS' SHIPBUILDING AND ENGINEERING COMPANY, LTD., GREENOCK.

(*For Description, see Page* 652.)

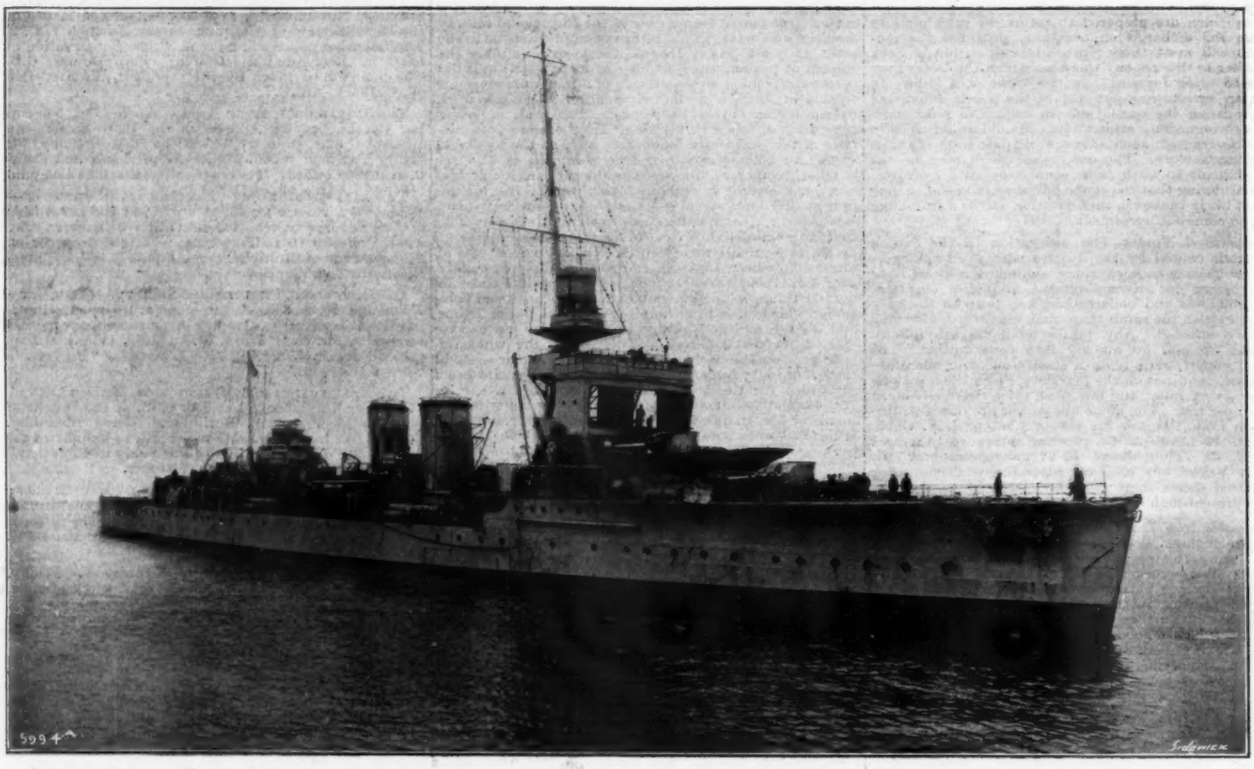


FIG. 1. THE SHIP READY FOR SERVICE.

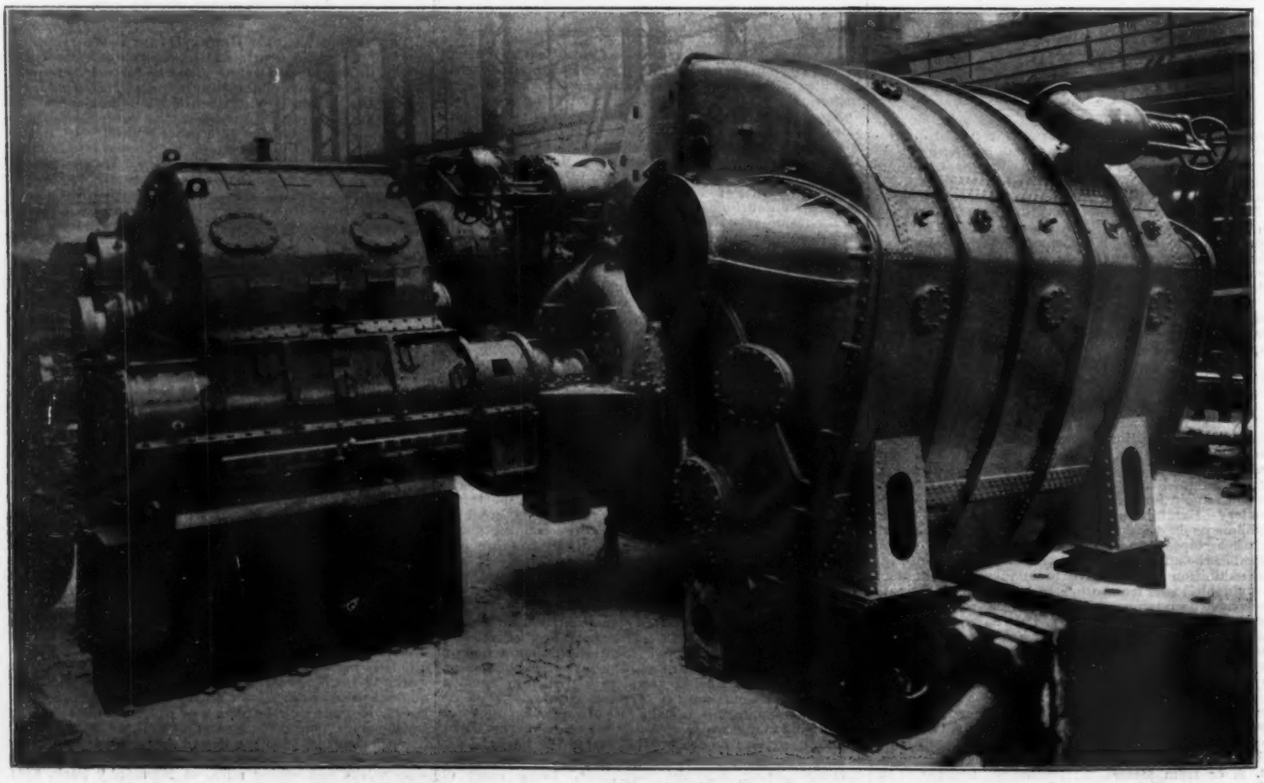


FIG. 2. ONE SET OF BROWN-CURTIS GEARED TURBINES.

# 20-H.P. SIX-CYLINDER MOTOR CAR AT THE OLYMPIA SHOW.

CONSTRUCTED BY MESSRS. WOLSELEY MOTORS, LIMITED, ENGINEERS, BIRMINGHAM.

*(For Description, see Page 644.)*

*Fig. 1.*

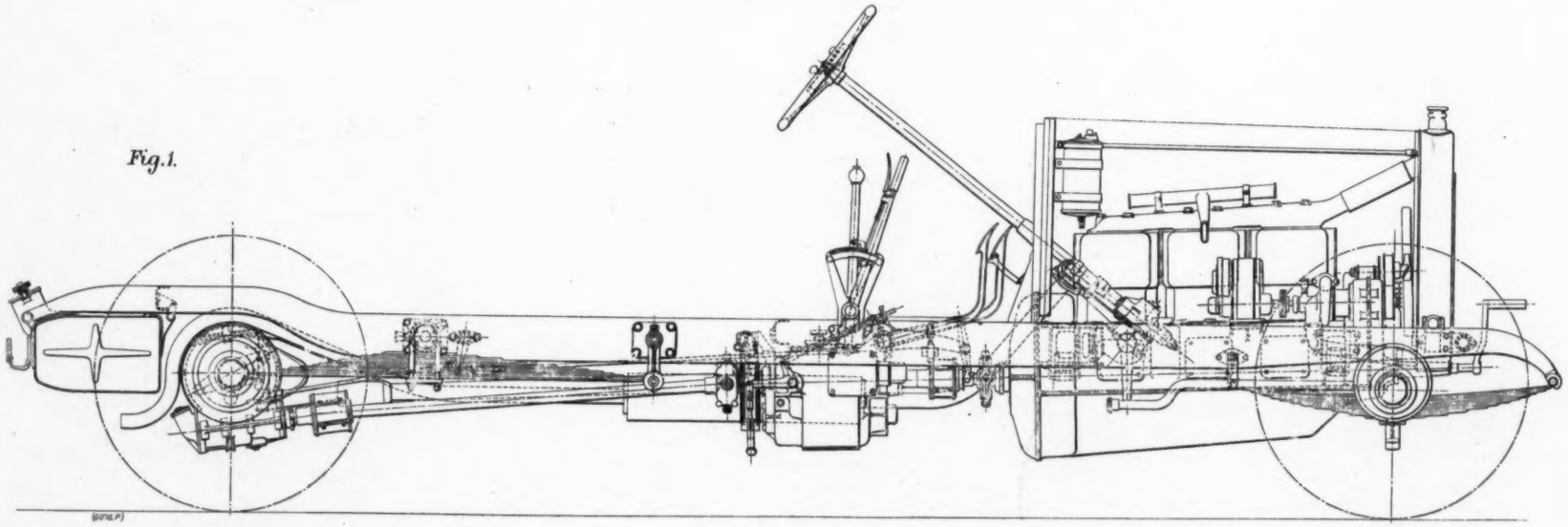
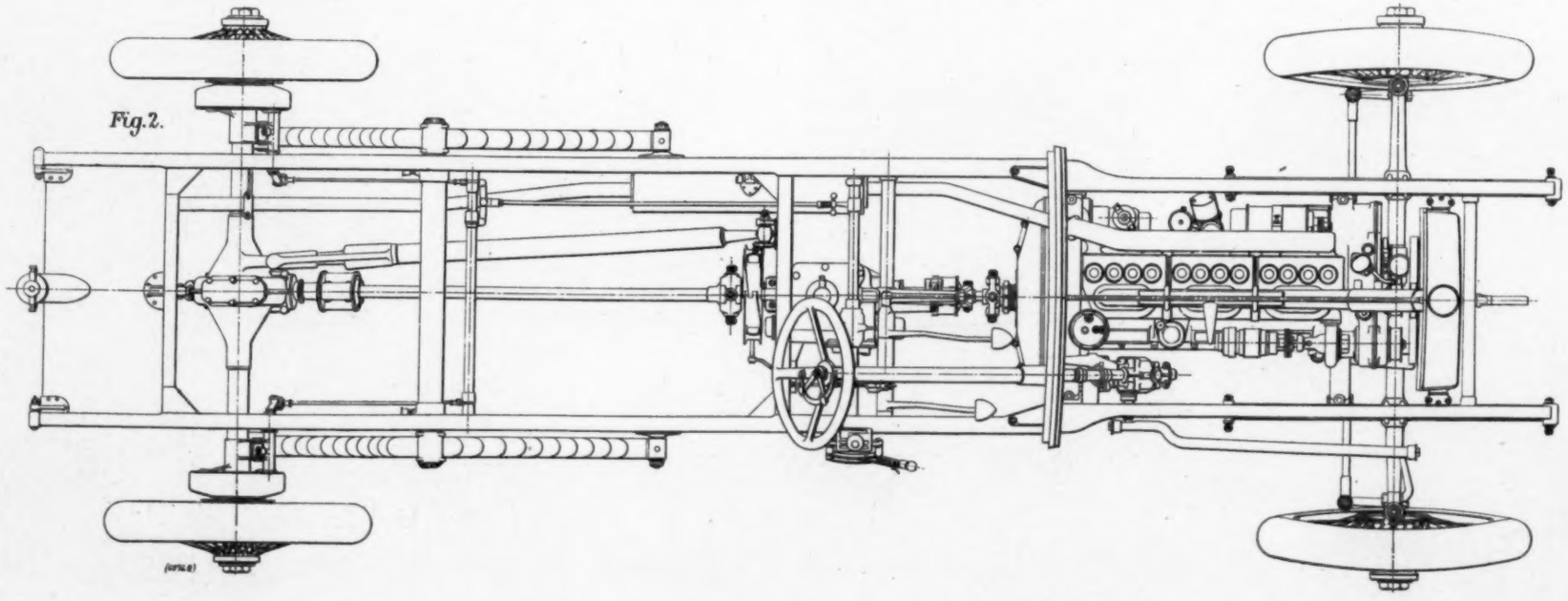


*Fig. 2.*

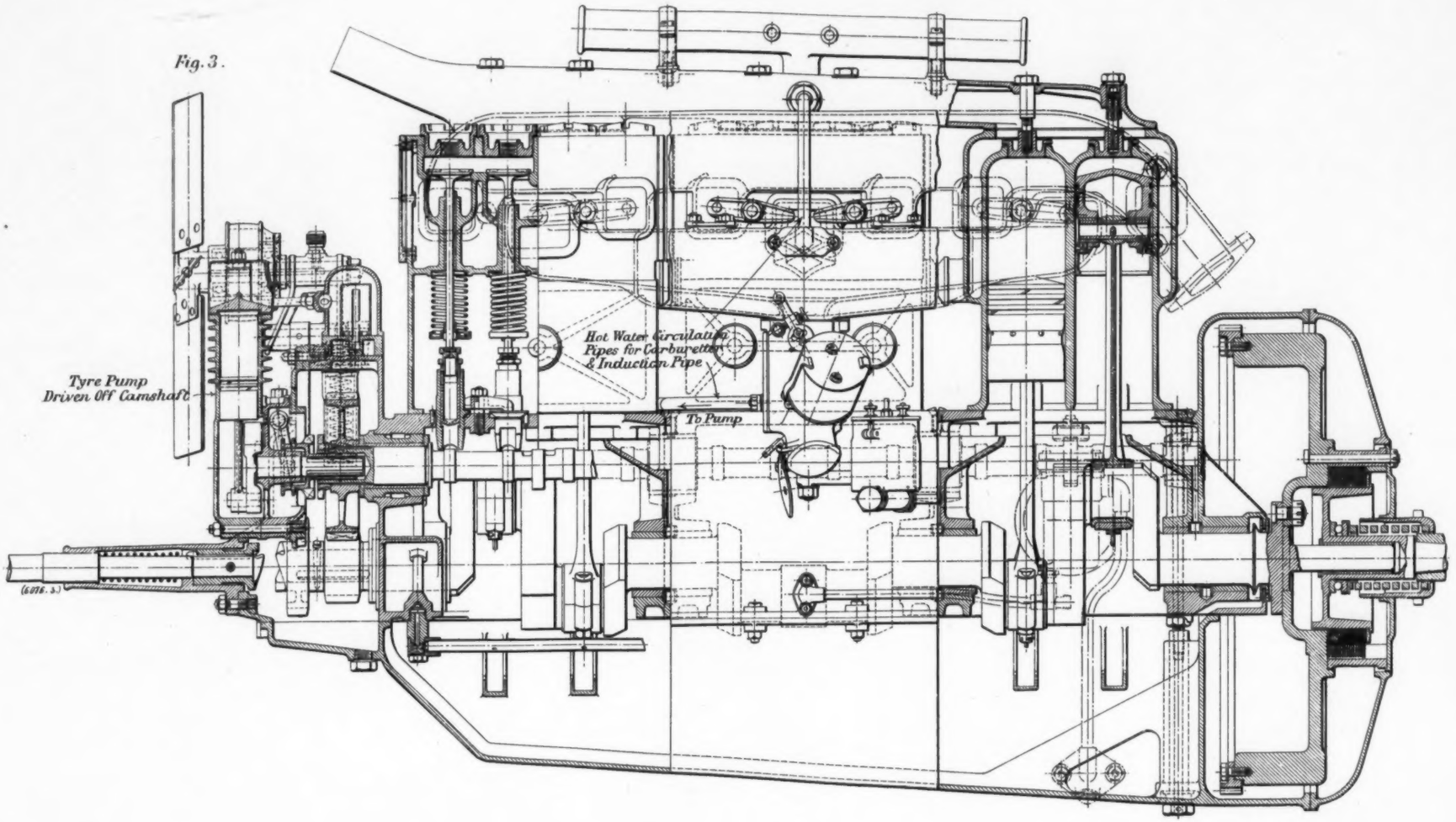


# 20-H.P. SIX-CYLINDER MOTOR CAR ENGINE AT THE OLYMPIA SHOW.

CONSTRUCTED BY MESSRS. WOLSELEY MOTORS, LIMITED, ENGINEERS, BIRMINGHAM.

(*For Description, see Page* 644.)

*Fig. 3.*



# 40-H.P. SIX-CYLINDER MOTOR CAR

CONSTRUCTED BY THE LANCHESTER MOTOR COMPANY

(For Description, see Page

*Fig. 1.*

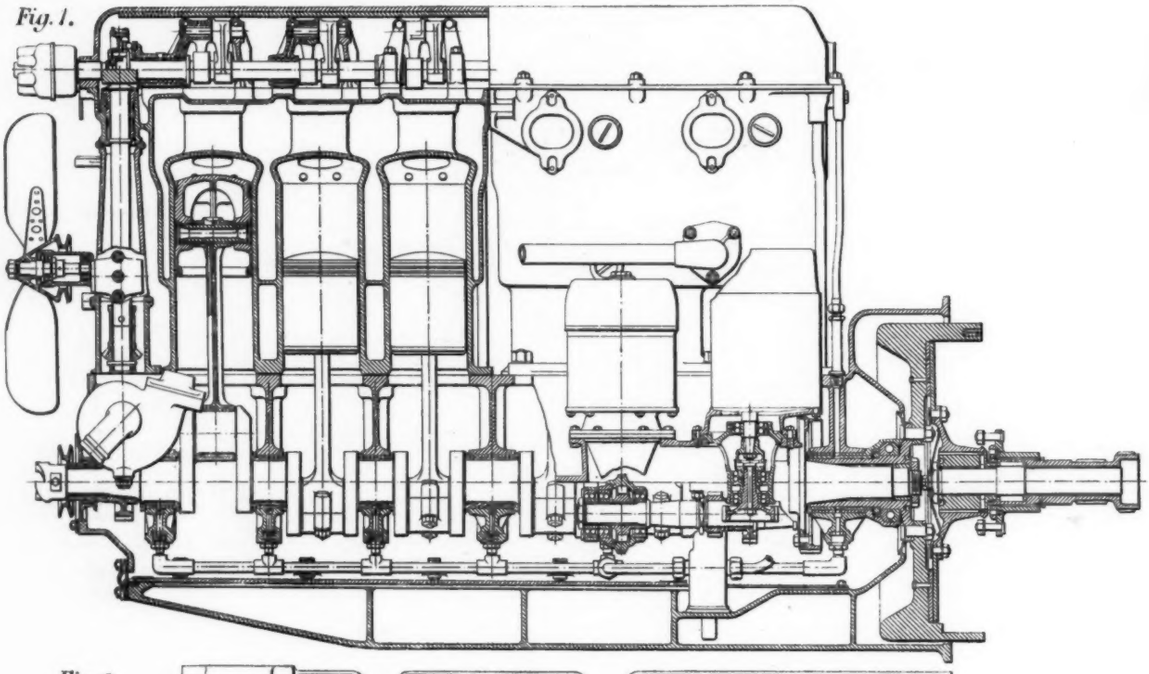


*Fig. 2.*

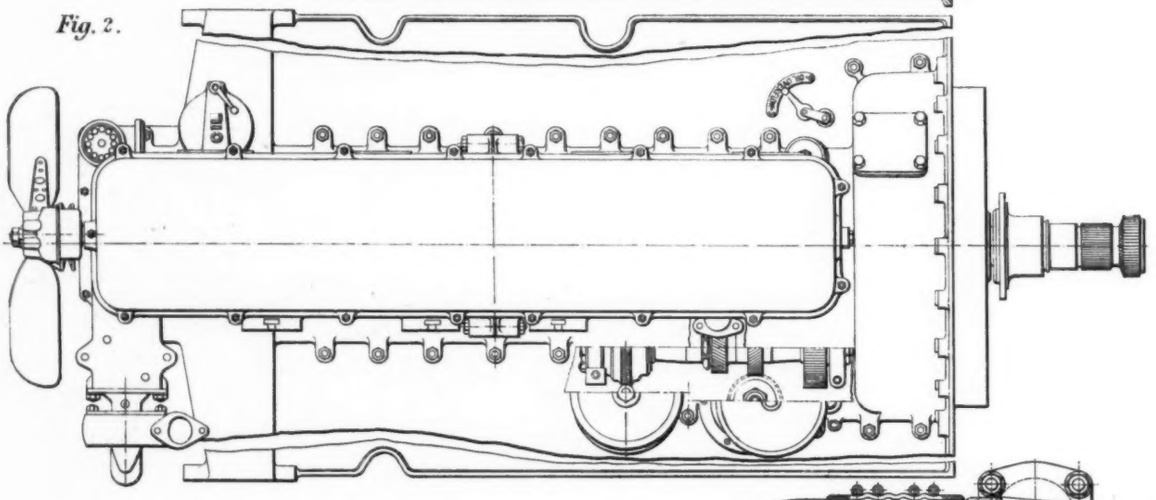



*Fig. 3.*

*Fig. 4.*

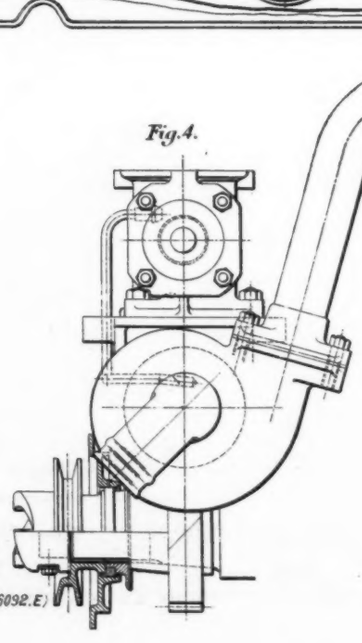
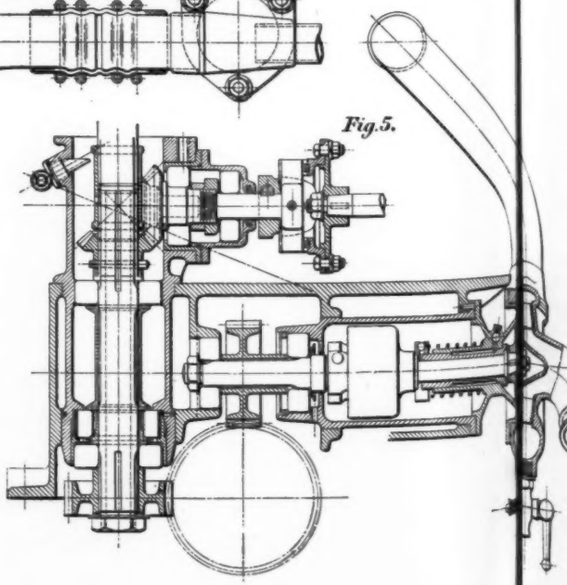


*Fig. 5.*



# OR CAR AT THE OLYMPIA SHOW.

MOTOR COMPANY, LIMITED, ENGINEERS, BIRMINGHAM.

(Description, see Page 642.)

Fig.3.

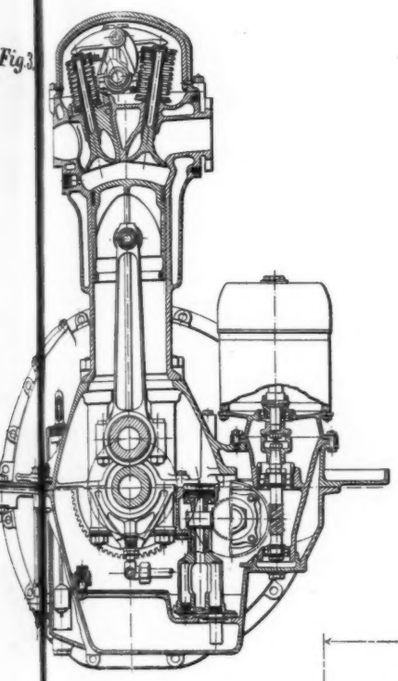


Fig.6.

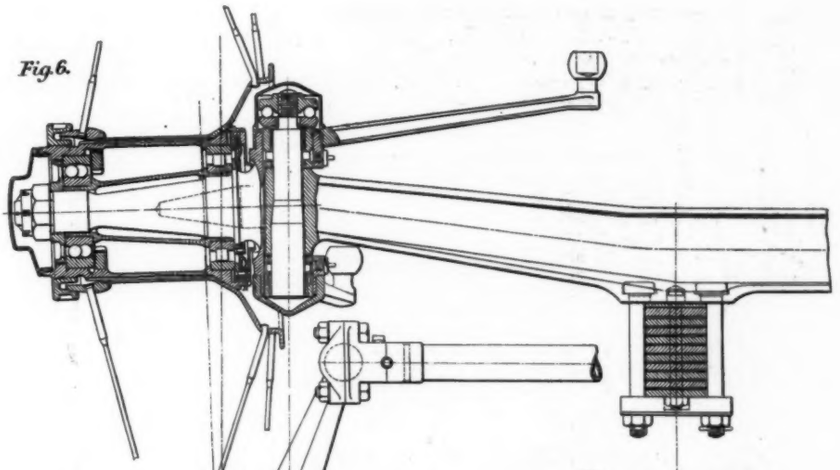
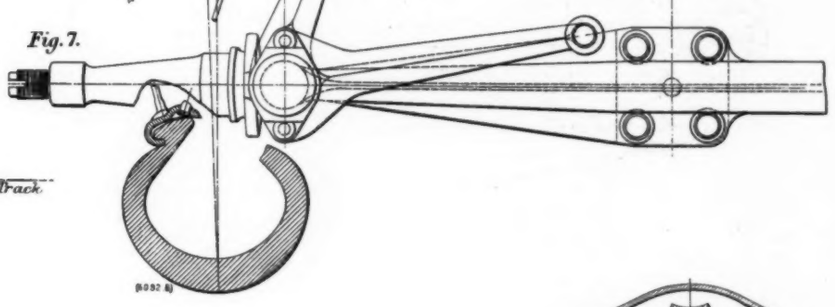


Fig.7.



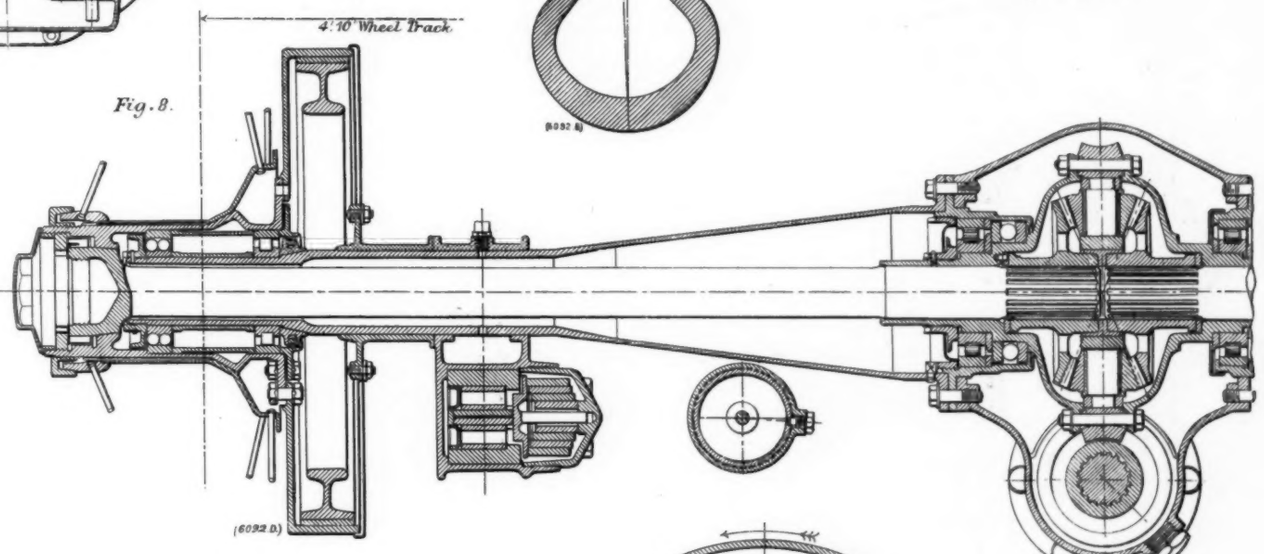



Fig.8.

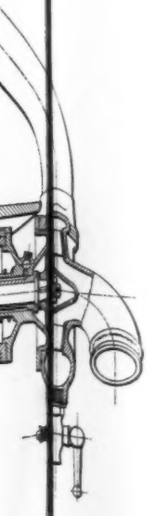


Fig.10. SECTION AT A.B.

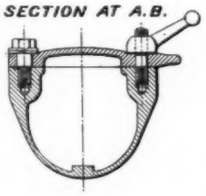
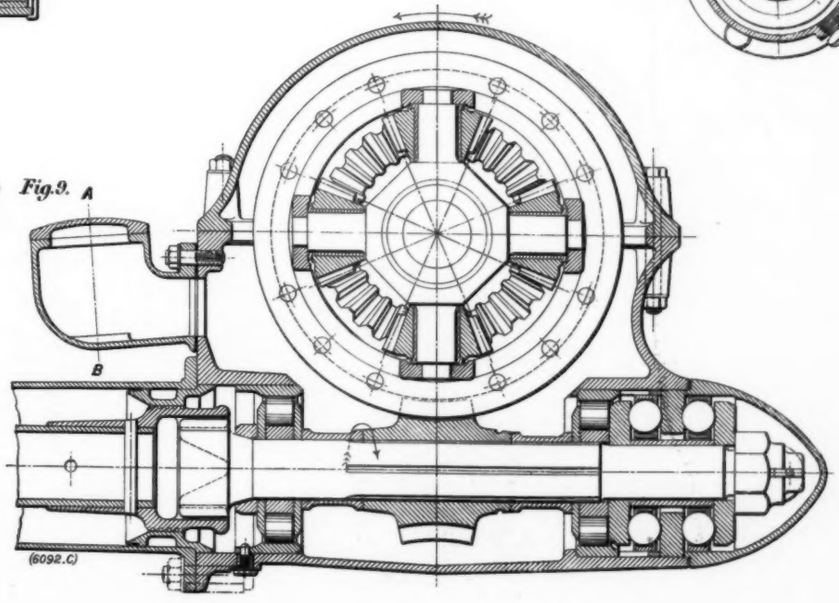


Fig.9.



# 20-H.P. SIX-CYLINDER MOTOR CAR ENGINE AT THE OLYMPIA SHOW.

CONSTRUCTED BY MESSRS. WOLSELEY MOTORS, LIMITED, ENGINEERS, BIRMINGHAM.

(*For Description, see Page* 644).

*Fig. 4.*

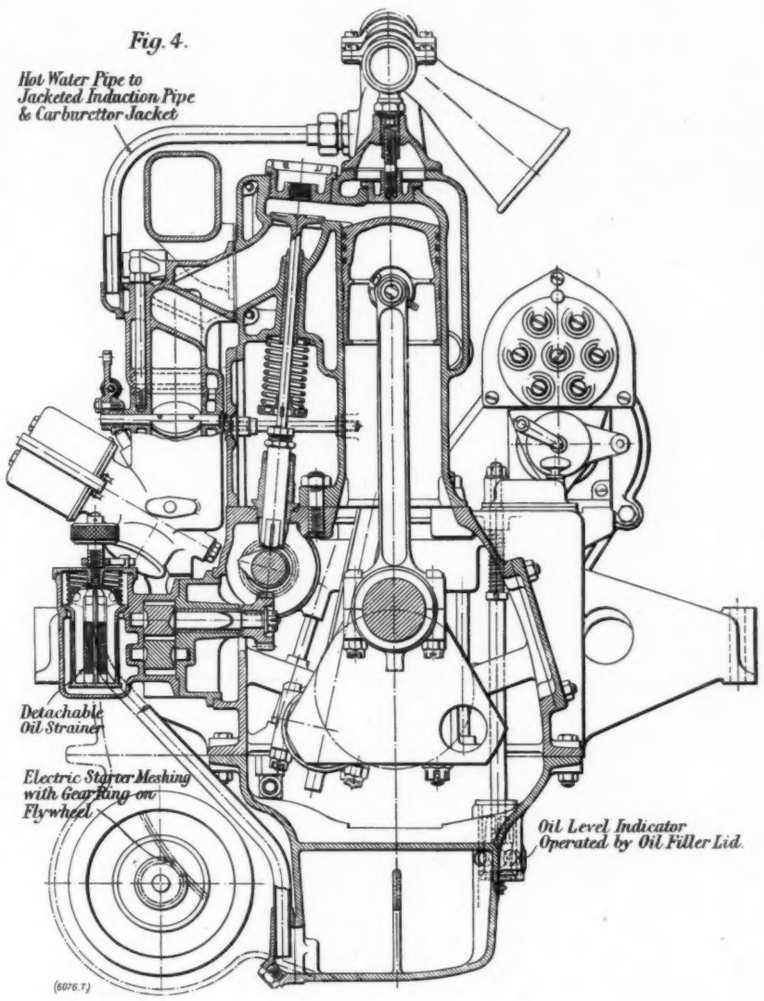

Hot Water Pipe to Jacketed Induction Pipe & Carburettor Jacket
Detachable Oil Strainer
Electric Starter Meshing with Gear Ring on Flywheel
Oil Level Indicator Operated by Oil Filler Lid.
(6076.T.)

*Fig. 5.*

SECTION THROUGH MAIN JET

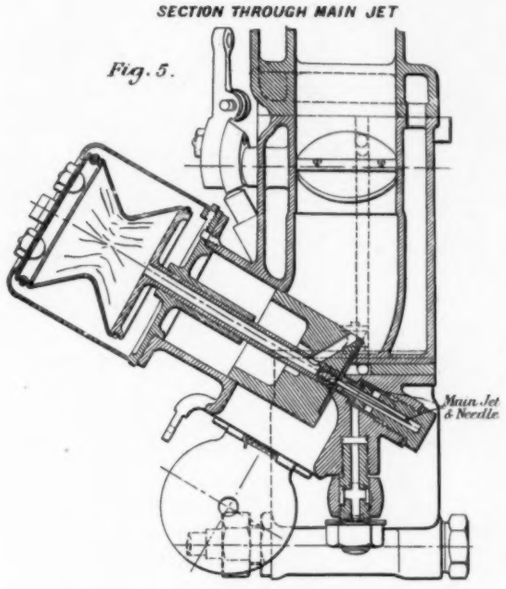



*Fig. 6.*

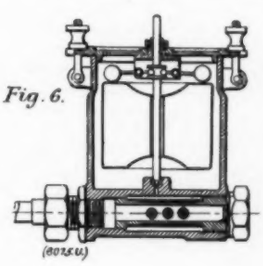



*Fig. 7.*

SECTION THROUGH AUXILIARY JET

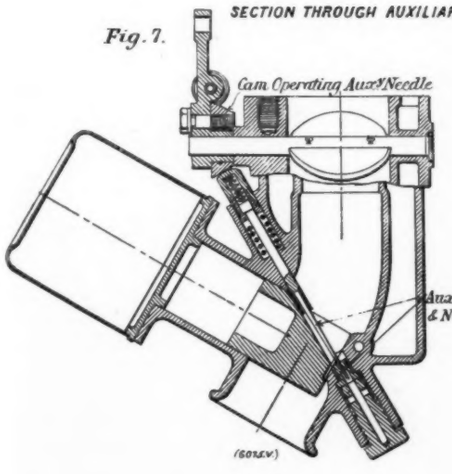



*Fig. 8.*

SECTION THROUGH SLOW RUNNING PASSAGES

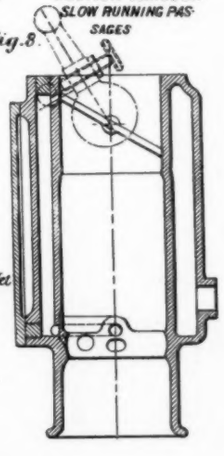


*Fig. 9.*

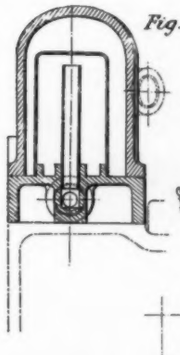


*Fig. 10.*

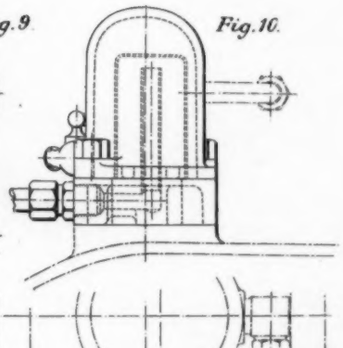
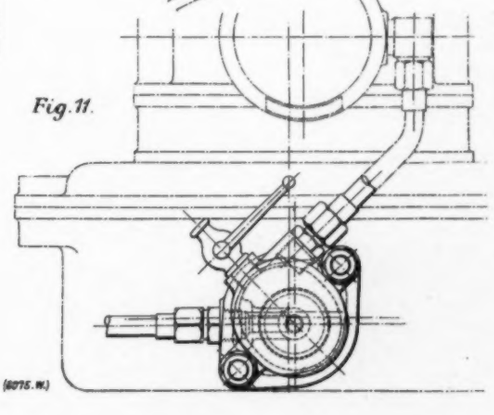


*Fig. 11.*



# 20-H.P. SIX-CYLINDER MOTOR CAR AT THE OLYMPIA SHOW.

CONSTRUCTED BY MESSRS. WOLSELEY MOTORS, LIMITED, ENGINEERS, BIRMINGHAM.

(*For Description, see Page* 644.)

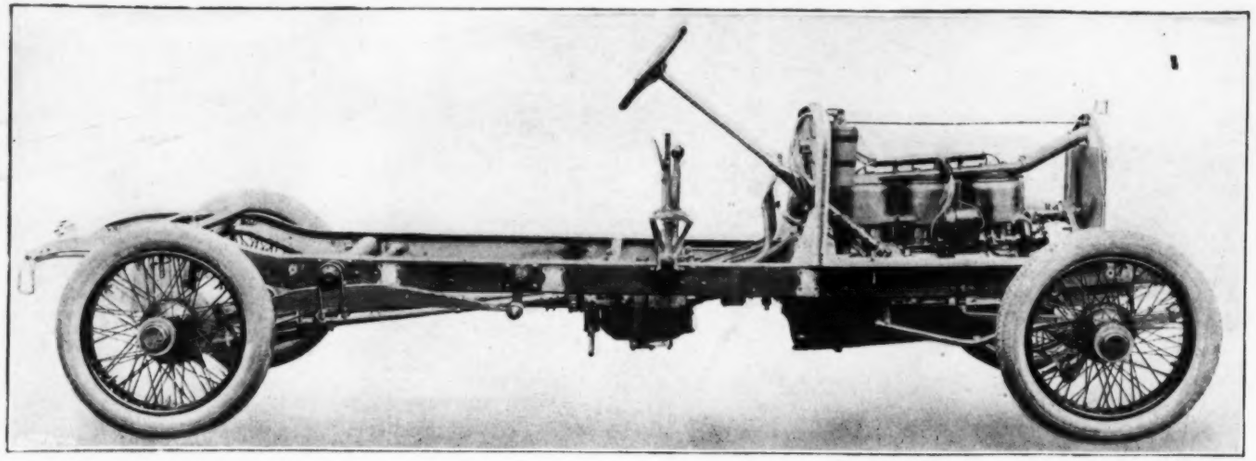


FIG. 12. GENERAL VIEW OF CHASSIS; OFF SIDE

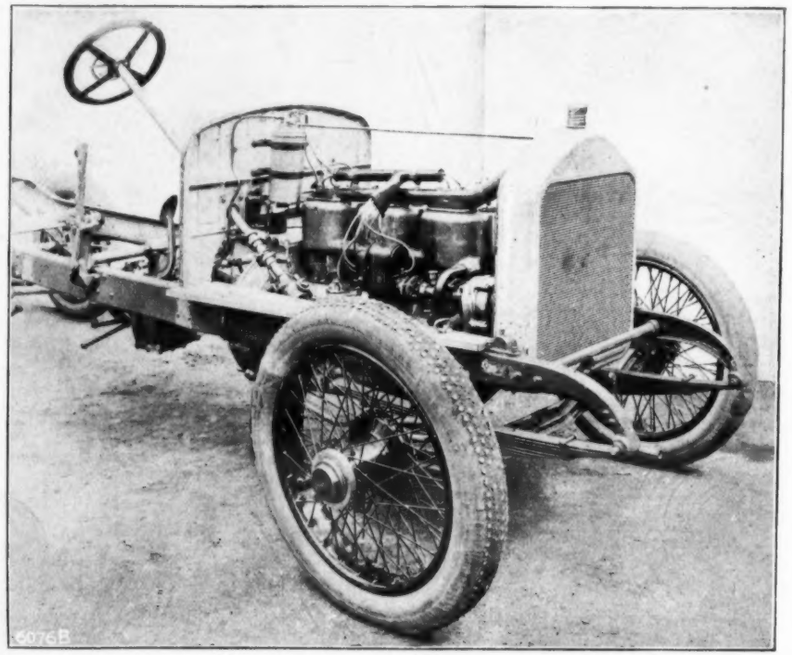


FIG. 13. FORWARD END OF CHASSIS.

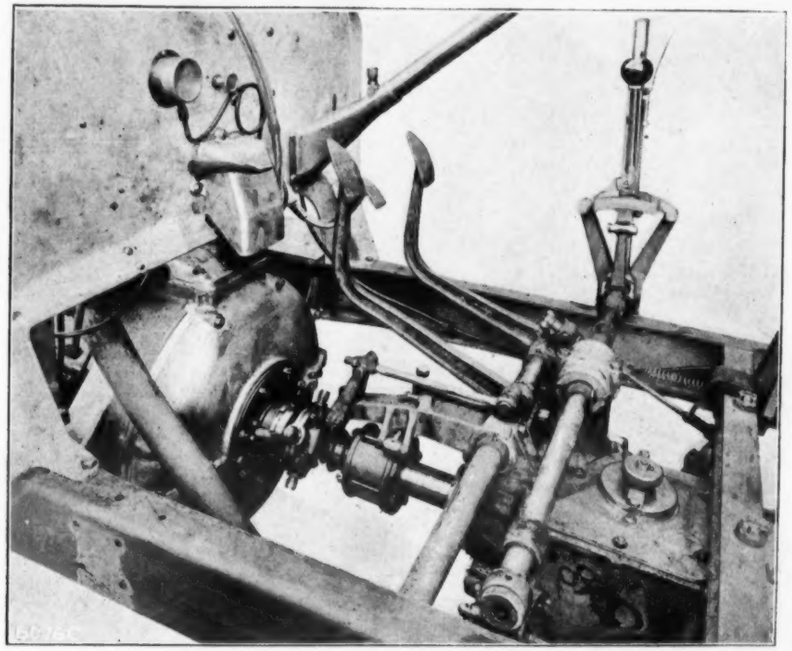


FIG. 14. VIEW SHOWING GEAR-BOX AND CONTROLS.

(*To face page* 645.)

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**Advertisements intended for insertion in the current week's issue must be delivered not later than First Post on Thursday. In consequence of the necessity for going to press early with a portion of the edition, alterations for standing advertisements should be received on the Friday previous to the day of publication.**

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All accounts are payable to "ENGINEERING," LIMITED. Cheques should be crossed "The National Provincial and Union Bank of England, Limited, Charing Cross Branch." Post-Office Orders should be made payable at Bedford Street, Strand, W.C. 2.

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TELEGRAPHIC ADDRESS } "ENGINEERING," WESTRAND, LONDON.

TELEPHONE NUMBERS—8863 and 8596 GERRARD.


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*With One Two-Page Plate of a 40-H.P. SIX-CYLINDER MOTOR CAR AT THE OLYMPIA SHOW, and Four One-Page Plates of a 20-H.P. SIX-CYLINDER MOTOR CAR AT THE OLYMPIA SHOW.*

## NOTICE.

**Owing to the enormous increases in the cost of paper, engravings, and printing charges generally, the Proprietors of "ENGINEERING" are compelled to advance the price of this Journal further from 9d. to 1s. per copy. This increase will date from and include the issue of Friday, January 2, 1920. The change will not apply to unexpired subscriptions. The revised rates for new subscriptions are given in the adjoining column.**

### NOTICE TO NON-SUBSCRIBERS.

**In view of the restrictions still imposed by the Government on the importation of paper and the consequent shortage of supplies, Newsagents will not have copies for chance customers: therefore readers who wish to be sure of obtaining "ENGINEERING" each week should place an order for the Journal with a newsagent or bookstall clerk.**

### NOTICES OF MEETINGS.

**Notices of Meetings to take place during the present and next week will be found on page 653.**

# ENGINEERING.

*FRIDAY, NOVEMBER* 14, 1919.

## PROGRESS IN MOTOR CAR DESIGN.

IT is impossible for an engineer to visit the Motor Car Show at Olympia without being impressed by the change that is coming over car design in its mechanical features. This change has not been made suddenly, but like the changes in nature has been usually of the character known as a "sport," and no adversion to a new type so introduced has perhaps taken place for a year or two, till, having been weighed for advantage and disadvantage it has been found to have greater merit than the previously popular practice.

In its early days, in the 'nineties, the car was dependent on its performance on the race-course. As power increased it became necessary to put the heaviest unit, the engine, far forward, so as to provide a sufficient moment not only to balance the torque on the driving wheels, but also to give enough load on the steering wheels to enable them to keep the road. The driver's seat was moved backwards to a position slightly behind the centre of the wheel-base, and the finished car, intended to carry an ordinary body and to be used for travel at more moderate speeds, retained the most comfortable part for the driver, relegating the owner or his passengers to seats over the back axle or even behind it. In the first decade of this century the influence of touring clubs was felt, and such trials as those made under the regulations of the Scottish Automobile Club left their impress on design. This influence was of a more subtle character than that of mere speed and endurance tests, and it showed itself in improvements of detail to obtain greater reliability, better hill-climbing and economy in fuel and water. Then, after routes, which a few years before would have been considered almost impracticable, had been traversed throughout by many cars with a large percentage of successes, the more natural causes for development received recognition. Questions of the comfort of the passengers, ease of access and facility for adjustment and repair, as well as durability, obtained attention. Up to that time, however, the car had been generally considered in its composite aspect—the chassis, comprising the whole of the propelling machinery with its supplies and their containers, being the work of one firm or of the engineering side of that firm—and the body and all that pertained thereto—wind screens, steps, wings and hood—coming into the province of the coach builder. The early railway coach closely resembled the stage coach of its own period, and the first motor car resembled the sledge even in that curled ornamentation to be found at the front end of the bottom side (or longitude as the railway coach builder would term it), a relic of the past as little useful to the car body, as is the coccyx or the vermiform appendix to man himself.

To-day the lesson of the engineers' war is apparent in very many of the designs now on exhibition. In the first place the fact that the pressed-steel chassis is not interchangeable within limits approaching those of machine-shop work has been appreciated. Evidence of this is to be found in the large number of chassis in which the engine and gear-box are built up as one unit with an open or closed intermediate well containing the clutch. In the days when clutches required frequent attention this would have been very undesirable, but the clutch having become relatively as reliable as other parts of the driving mechanism, it now can be encased without cause for misgiving. The manufacturer having made one unit of the engine, clutch and gear-box, the question of the pressed steel chassis again arises, this time in a twofold way, firstly by reason of inherent want of truth, secondly because of change produced in it when loaded with the body, and also by the stresses produced in travelling. This has been recognised both in England and in America, and it is curious to note that, whereas British practice favours a three-point suspension by two lugs on the engine casing in front of the flywheel and a single central support at the back of the gear-box—the American generally adopts the converse arrangement carrying the front of the engine on a single central bearing and having its two side supports near the engine flywheel. This system of construction would have been impracticable with the earliest designs of engines—those in which the half bearings were carried in the upper and lower halves of the crankcase—because in such engines accurate alignment could not be obtained. In the modern design with the crank-shaft bearings carried in the upper half of the casing there is no initial difficulty, but the repairer will be wise if he fits a new set of bearing liners instead of making any alteration to the upper halves of the main bearings. A very small change in the position of the axis of the crankshaft is inadmissible with the short and rigid connections now made between it and the gear-box in this form of construction. In those chassis, of which there are many examples, in which there is a space between the engine and the gear-box and the change in design is not fully completed, recognition of this possibility is seen by the provision of one, or in some cases two, flexible couplings between the engine and the gear-box. When these units are mounted on a sub-frame, which itself is not a machine-shop job, the whole system is thus equipped with compensation for want of axial continuity. The placing of the gear-change lever in a central position on the top of the gear-box, or even the arranging of a sideway extension carrying the gear-change lever and brake lever independently of the frame, affords further evidence that relative change of position is expected between the power unit and the frame on which it is supported.

Another change which is coming over chassis design is the tendency to give direct alignment from the engine and gear-box through the propeller shaft to the back axle. This is usually much closer than it appears from inspection of the unloaded chassis, and is obtained in various ways because the conditions differ greatly. Generally the fact of the engine being smaller and running at higher speed has permitted its centre line to be brought lower. In some cars with worm-driven back axles the solution has been found at once by placing the worm on the top of the axle and providing special means for ensuring lubrication of the worm, as well as of its bearings. In many cases, particularly where a sub-frame is fitted, it would be possible with bevel back-axle drive to obtain direct alignment by slightly inclining the axis of the crankshaft and gear-box to the requisite extent to give alignment when the chassis is under normal load. The angle necessary is small compared with that assumed in hill-climbing; it is, in fact, an inclination which, in Alpine or sub-Alpine travel may obtain for hours on end, and cannot therefore be regarded as abnormal. This reduction of angularity between the propeller-shaft axis and that of the power and speed-change units finds further recognition in some cases by the substitution for the cardan joint of a flexible joint consisting of steel and fibre, of vulcanised fabric, or of composite materials. This arrangement was tried some thirteen years ago, but, though it worked well, even under the worse conditions of considerable axial angularity, it was abandoned on

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account of certain disadvantages which possibly are not serious under the present conditions considering the experience of these couplings that has now been obtained.

Design has also been subject to modifications brought about by factory conditions. In the very early days the cylinder casting was the greatest difficulty in the engine. Even though a perfectly sound casting was obtained the cleaning out of the water jackets and of the pockets round the valves was a matter of serious difficulty. This is very greatly reduced by making the cylinder heads detachable, a feature in which motor-engine construction is reverting to very early gas-engine practice. Having simplified the cylinders to this extent a further step is taken by casting all the cylinders in one with the upper half of the crank-case, a method which involves small increase of weight when all factors are considered. This reduction in number of parts having been obtained, the valves and in some cases also, the camshaft, are placed overhead and themselves covered in by a casing so that dust and dirt are excluded. The engine then becomes as thoroughly enclosed as the latest types of high-speed steam engines. It is, however, a result that could only be obtained when sufficient experience had been gained in valve construction and valve material, in the strength of springs required and in the attachment of the collars to the valve stems, all of which are the outcome of aero-engine development during the war.

In other essentials of the chassis the trend of progress is less well marked. The back axle drive is occasionally by worm, but more frequently by spiral bevel; in one instance a unit comprising the bevel pinion, shaft and housing, with the bevel wheel and differential, can be withdrawn complete from the gear-box and the actual engagement of the teeth examined. Hitherto it has only been possible to estimate the error of engagement by careful measurement and comparison on a section of a dummy gear-box, and to verify it by running a strip of thin paper through the gears in their final position. The design described, though slightly more elaborate is, however, another step in the direction of rendering assembly more easy by adopting detail arrangements capable of being inspected individually. At least two worm gear drives are similarly assembled, and afford examples of detachment either from the front after the axle is removed from the chassis or from the back with the axle in place, in both instances with the floating axles drawn out of engagement. At present it is not possible to find any quite definite trend in practice for the transference of the torque and thrust from the back axle to the frame; these are still taken indifferently by the propeller shaft casing, or by the springs alone, or partially by the springs and by radius rods. In the front springs there is almost definite agreement on the semi-elliptic type, very few examples differing in this respect. In the back springs there is still great variety, in fact, there are very many examples of ordinary semi-elliptic springs, of the same type, underslung, and of cantilevers. Both the latter arrangements excited adverse comment, not to say derision, when introduced over fifteen years ago. Steering, with rare exceptions, attained to a standard style early in the history of the development of car design, but the road wheels have in recent years undergone rapid change, the steel wheels, whether welded or with wire spokes, or of disc pattern, now outnumbering the wooden wheels in the ratio of about four to one.

It is, however, in the tendency to recognise the comfort of the owner and driver as essential, that design has made the most revolutionary change. Before the war the self-starter was a luxury—now the car models shown with self-starters are at least five times as numerous as those without. The introduction of these appliances has generally carried with it electric lighting, and in many cases also an addition to the ignition system. Cars of as low as 10 h.p. are now fitted either with a self-starter or with a hand starter, which enables the driver to get his engine going without dismounting.

The enclosing of gears, of valves, of clutches, and of many other details would seem to a man who had only driven very old makes of cars to involve dangerous departures from safe practice and to be a distinct step towards creating inaccessibility. This is really not the case, for it will generally be found that although a clutch may now be enclosed and the wearing parts protected from wet, mud and grease, the part that actually requires adjustment, that is the spring, has been brought to the outside. The same applies to the brakes, the design of the e being so modified that adjustment can be performed readily, without special tools and on a part which is easy of access.

It is in the bodywork of the car that the march of progress is most likely to produce change in method, if not in outer form. In the 'nineties body space was grudgingly released by the chassis builder, and the word "compromise" was writ large all over the tonneau. To-day the specification shows exactly where the chassis ends and the coach work commences, everything connected to machined parts is carried on the chassis up to and including the instrument board, which on some of the more costly cars is very elaborate. It includes electric switches, voltmeters, engine-revolution indicator, a car-speed indicator, a petrol gauge and a clock; in fact, if a height-indicating barometer, were added for use on mountain roads, a thermometer for the temperature of the cooling water, and a compass as a guide in the event of getting lost on dark nights, the fittings would nearly equal those of the aeroplane.

Coachwork to-day has reached the stage at which the artist is brushed aside by the producer. The designs of car bodies are falling into a few standard styles—open, partially enclosed, and wholly-enclosed—two, four or more seated. The lines are becoming more stereotyped, and originality is losing ground. But this change is as inevitable in the car as it was in the public service vehicle. We cannot do all our reading from *incunabula* or first editions, but for the matter of the day we must take the products of the Linotype or Monotype and of the Hoe press; similarly, we must accept the mass-produced car body for much of our future travelling. This change has occurred before in the industry when railway coaches were required in large numbers, and the history of that change, as written in the works, shows that there is no need for despair among the highly skilled coach builders, for real skill will always command its market. Of high-class coach work there is no dearth, as is evidenced in the fine examples exhibited, the results of the best efforts of men who have worked wood as a material they loved. They have humoured it for form and fibre, drilling each screw hole to two sizes for thread and shank, countersinking to the proper depth and bringing the nicks of the screws in line with the grain; they have attained a finish perhaps beyond that of the shipwright's cabinet-maker. These men can go to the show and feel proud of their work. They have had little chance to show to connoisseurs their coachwork as it should be shown, that is before it is filled, painted and varnished, for then one can see as the gods see, and the tradesman can point to his handiwork with justifiable pride in joints so well fitted that they will remain sound after years of racking on the road.

## THE COOLING EFFECT OF CARBON DIOXIDE IN FLAMES.

The remarkable effect of an excess of carbon dioxide in lowering the temperature of flames has long been known. Thus when the South Staffordshire power gas scheme was before Parliament some eighteen years ago, it was given in evidence that Mond gas could not be used for incandescent gas lighting since, owing to its considerable content of carbon dioxide, the flame temperature was far below what was required for this purpose. Striking confirmation of this peculiarity of carbon dioxide is afforded by the experiments described by Major W. T. David in our issue of September 5 last. In this case carbon dioxide was substitute for nitrogen in the mixture fired in an explosion chamber, and the temperature attained was found to be lowered in a remarkable degree. This is well shown by the figures tabulated in the next column, which have been taken from one of Major David's tables.

| Percentage of Coal Gas. | Percentage of Oxygen. | Percentage of $CO_2$. | Percentage of Air. | Maximum Temperature Attained. |
|---|---|---|---|---|
| | | | | deg. C. |
| 15 | 26·4 | 58·6 | — | 1720 |
| 15 | 19·7 | 65·3 | — | 1340 |
| 15 | — | — | 85 | 2400 |

It was further noticeable that in the case of the air mixture the maximum temperature was attained in less than one-twentieth of a second, whilst with the 58·6 per cent. $CO_2$ mixture the maximum temperature was recorded about one-sixth second after ignition, and for the case in which the carbon dioxide amounted to 65·3 per cent., nearly half a second elapsed before the maximum temperature was reached. The lowering of the temperature is certainly not due to the higher specific heat of $CO_2$, as Major David pointed out in his article. In fact, at low temperatures, the volumetric specific heat of carbon dioxide is less than that of nitrogen. At high temperatures it is, however, slightly higher. Thus at the Leicester meeting of the British Association in 1907, Dr. Holborn, of Berlin, exhibited a diagram from which it appeared that at 1,400 deg. C. the value of $Cp$ for $CO_2$ was about 0·27 that of nitrogen, being about 0·262. The corresponding values of $Cv$ will probably be about 0·21 and about 0·19 respectively. As Major David observed, the difference in the maximum temperatures recorded is out of all proportion to the difference in the specific heats. He suggested in his article that "the vibratory degrees of freedom of the inert $CO_2$ molecules rapidly absorbed energy from the freshly-formed molecules which are known to possess at the moment of formation a considerable excess of vibratory energy over and above the amount" due to the temperature.

If, however, the views recently brought forward by M. J. Perrin, the distinguished French physicist, be well founded, there would seem reason to believe that the remarkable lowering of temperature effected by admixtures of $CO_2$ is really due to dissociation of this gas. M. Perrin contends that every chemical reaction is provoked by a luminous radiation. The velocity of the reaction is determined by the intensity of this radiation and only depends on the temperature in so far as the intensity of the radiation depends on the temperature. It is generally acknowledged that when two atoms combine chemically the rate of radiation is far greater than it would be, from the compound molecule raised by external means to the same temperature. In fact, the energy developed in the act of combination is only gradually converted into the form of heat, and is represented at the outset by the vibrations or other motions of the valency electrons. Hence, if M. Perrin's view be correct, the dissociation of the carbon dioxide in Major David's explosion vessel should be far more than that corresponding to the temperature of the mass of gas.

The energy absorbed on the dissociation of $CO_2$ is very large, and if this view be accepted the remarkable cooling effects observed by Major David are easily intelligible. In support of his views, M. Perrin notes that in certain cases the rate of dissociation of a gas does not depend on its dilution, so that the dissociation cannot be solely due to molecular encounters. If the volume occupied by such a gas is increased tenfold the rate of transformation per unit volume is one-tenth as great as formerly or as much in all. When concentrated, however, the number of molecular encounters is correspondingly greater, and were these directly responsible for the dissociation, the rate should be higher in the concentrated than in the rarefied gas.

## THE POLLUTION OF THE ATMOSPHERE.

The committee charged with the investigation of atmospheric pollution have published their fourth report, together with the results of observations made in the year 1917–18 at 24 selected stations in Great Britain. With the resumption of peace conditions the committee hope to be able to collect results from a larger number of stations, though activity has been fairly well maintained. As in former reports, the condition of the atmosphere at Newcastle-on-Tyne and at Malvern has been

contrasted, these stations giving respectively the highest and lowest deposit of all the stations from which complete and trustworthy analyses are available. At the former, the mean monthly deposit of the solids contained in the atmosphere amounts to 20·81 metric tons per square kilometre; at the latter only 2·51 tons. Both stations increased the deposit in the summer months of 1916–17 and diminished it in the winter months, but where the variations from month to month are considerable little inference can be drawn from this fact. At Newcastle, for example, the solid matter varied from 44 metric tons to 11 metric tons, and the maximum month was April, which lies about midway between the extreme seasons. Generally there is a tendency at all the stations for the amount of solid matter to increase during the summer, and also there is some indication of an improvement in the state of the atmosphere during the winter. London, somewhat exceptionally, shows an improvement in both winter and summer, but it is important to note that the sources of pollution differ considerably in the two seasons. In summer, dust raised by the wind forms the preponderating share, in the winter the dust from fires. At Glasgow, in contrast to London, there are signs of increased atmospheric pollution in both summer and winter.

Dividing the impurities in the atmosphere into two classes, the insoluble and the soluble, the former including tar, carbonaceous matter other than tar, and insoluble ash, while the principal ingredients of the latter are sulphates, as $SO_3$, chlorine and ammonia, it is possible to trace the seasonal variation of each. Considering these elements of pollution in the atmosphere during the years 1916–17 and 1917–18, the results from the whole group of stations show that the deposit of carbonaceous matter was less during the summer months. Insoluble ash shows a great increase during the summer months, and a slighter increase during the winter months of the two periods. The sulphates, which are derived mainly from combustion products, show a diminution in the summer months and an increase during the winter months of the two periods. It is suggested that the explanation is to be found in the less fuel consumed in the winter of 1917–18. Chlorine deposit was the same for both summers. From an examination of the mean monthly deposits for the whole year, and for different stations, it appears that Malvern had the lowest deposit of all elements of pollution, and curiously enough, the second lowest in seven cases out of nine was Wandsworth Common, London.

A comparison of the incidence of deposit in different months of the year in typical cities as London and Glasgow leads to somewhat unexpected results, for the generally similar conditions at two thickly populated centres do not lead to like results. An analysis shows that all the elements of pollution, whether soluble or insoluble, differ in the time of their maximum and minimum deposit at the two cities. At Glasgow, insoluble matter shows its maximum deposit during the summer months, and the total soluble matter is most freely deposited during the winter months. There is no sign of any such seasonal variation in the metropolis. Sulphates show a maximum deposit in the winter months, ammonia on the other hand is distributed with fair uniformity throughout the year.

From previous analyses, rainfall has been shown to have no appreciable effect on the amount of insoluble matter in the atmosphere, but the influence of rain on soluble matter remained undecided. As it seemed not improbable that there would be a direct relation between soluble deposits and precipitation, this question has been the subject of further investigation. The conclusion derived by plotting the amount of the various impurities against rainfall is, that while the deposit of soluble matter is not strictly proportional to the rainfall, yet there is a general tendency for its amount to vary directly as the quantity of rain. The accidental variations are, however, too great to make any exact relationship pronounced. A straight line can be drawn to give, with some approach to accuracy, the numerical relation between the deposit of soluble matter and rainfall. If R denotes the rainfall in millimetres, and S the deposit of total soluble matter in tons, per square kilometre, then $S = 0{\cdot}058\,R + 2{\cdot}5$. Applying the same method of investigation to the results of former years, the following equations were derived:—

For 1915-16 ... $S = 0{\cdot}045\,R + 3{\cdot}2$
„ 1916-17 ... $S = 0{\cdot}047\,R + 3{\cdot}2$

There is a great similarity between these equations, but it is not suggested that they can be used to find the soluble deposit when the rainfall is known; the causes of deposit are too erratic. The velocity and direction of the wind, the height of gauge above the ground, and other disturbing factors into whose operation the committee have not inquired, would influence the result. Sulphates, chlorine and ammonia are the only deposits that vary more or less together, and this result might have been anticipated, as they all form part of the soluble deposit which is to a great extent governed by the rainfall.

## NOTES.

### The Jubilee Number of "Nature."

On the 6th inst. our contemporary *Nature* published its Jubilee Number, to which we have much pleasure in calling attention. *Nature*, which is well known throughout the world of science for the high standard of its contents and the eminence of its contributors, owed its birth to the energy and foresight of Sir Norman Lockyer, K.C.B., F.R.S., who edited it for many years, and who has contributed to the special number under notice some "Valedictory Memories." In this article Sir Norman reprints the circular in which were laid down the aims and intentions of the journal, the first issue of which appeared November 4, 1869, at a time when Tyndall, Huxley and Kelvin were in the prime of life. The Jubilee Number consists of some 40 brief articles, the general aim of which is to give a concise review of the progress of science during the last half century. The contributors include some 28 Fellows of the Royal Society, among whom are Sir Archibald Geikie and Sir J. J. Thomson. That science is no longer the Cinderella of intellectual pursuits is shown by the fact that 11 knights are among the contributors. Sir J. J. Thomson writes on "The Influences of Investigations on the Electrical Properties of Gases on our Conceptions of the Structure of Matter"; Sir Ernest Rutherford on "Radium and the Electron." "Atoms and Molecules" is dealt with by Professor Soddy, the "Ionisation of Gases" by Professor Townsend, "X-Rays" by Professor Bragg and Dr. Jordan, and the "Progress of Electrical Invention" by Professor Fleming. The articles on "Chemistry" are by Sir Edward Thorpe, Professor Armstrong, Professor Dixon and others, while Dr. Unwin writes on the "Developments of Mechanical Science" and Dr. Carpenter on "The Trend of Modern Metallurgy." "The Biological Sciences" are dealt with by Sir Ray Lancaster and "Medicine" by Sir Clifford Allbutt and Dr. Martin, who in his article on "Primitive Medicine since 1869," says that "during the last 50 years upwards of 10 years have been added to the mean expectation of life of a child born in Britain or in the United States of America," an interesting testimonial to the great improvements which have been made in curative remedies and preventive measures in the latter of which engineers have played an important part. It is impossible more than thus briefly to indicate the absorbing nature of the contents of this Jubilee Number; a number on the production of which the Editor is to be congratulated, and one entirely worthy of the inestimable service to the cause of science played by *Nature* during the last 50 years. One article—and a most interesting one—is appropriately devoted to the work of Sir Norman Lockyer, and this is from the pen of Dr. Deslandres, the Director of the Astrophical Observatory of Meudon, and a Vice-President of the Paris Academy of Sciences.

### Education of Engineers.

Although so much has been written and spoken on the subject of the education of the engineer, the question as to which is the most efficient method of training appears to be as far from settlement as ever. The reason for this is probably that there are so many variable factors which affect the results, that no system can be definitely allocated to the first place. Every system has produced both good and bad engineers, and some very successful men have received their training under conditions that would now be regarded as highly unsatisfactory by educational authorities. So much depends upon the characteristics of the individual that it is impossible to be dogmatic. The subject, however, is always of immediate interest to those about to set out on an engineer's career, as well as to those responsible for them, and it may therefore be useful to record the views of successful engineers, and others who have studied the question, in order to assist interested parties to make their own decisions. Sir William Ellis, G.B.E., D.Eng., has recently expressed his views on the subject of the training of mechanical engineers in an address to the Yorkshire Association of Students of the Institution of Civil Engineers, and these views may be helpful as we have suggested above. Sir William is of the opinion, and few will dispute it, that a successful career as an engineer is open to any young man of ordinary ability, provided he has the necessary strength of character and determination. With regard to the very vexed question as to the order in which practical and theoretical training should be given, Sir William holds the view that a boy should enter the shops immediately on leaving school, not only to gain some insight into machine shop operations and engineering processes, but more particularly to come into direct contact with workmen while at the most impressionable age. During this period, which should extend for about two years, the youth should endeavour, by evening study, to equip himself mentally for the University course he would commence at the end of his first term in the shops. In the case of youths going forward to the University to take a degree course after only two years practical training, Sir William considers it desirable for them, after completing the course, to return to the firm with which they commenced their training in order to gain experience in the drawing office, and also, possibly, to spend some further time in the shops. He also urges the importance to the young engineer of taking any opportunity which may occur towards the end of his training of doing some work abroad. The fact of being away from home, more or less upon his own responsibility, undoubtedly tends to develop character and self reliance in a young man, and these qualities will add materially to his prospects of success. Engineering, Sir William concludes, is a serious profession, and must be regarded seriously by all who enter it. At the same time he calls attention to the need for maintaining the proper relationship between work and play, considering a certain amount of the latter as essential a factor in making for success as anything else. Opportunities for young engineers, he considers, are greater to-day than ever before, owing to the fact that many such have given their lives in the great conflict, and others have been diverted by it from the careers on which they had already embarked. There is a dearth of young men of suitable training to take up positions of increasing responsibility in connection with the many schemes which will be put into operation all over the world as soon as financial conditions become more stable.

### Sale of Gas by Calorific Standard.

Sir Auckland Geddes, President of the Board of Trade, in replying recently in the House to a member's question as to the quality of gas supplied to consumers in the London area, said that he was aware that gas undertakings generally were supplying gas of a lower calorific value than was supplied before the war, but that this was being done, at the present time, with the approval of the Board of Trade, in order to secure an adequate supply to all consumers during the coming winter. He also added that he hoped shortly to introduce a Bill giving effect to the recommendations of the Fuel Research Board whereby gas will be charged for according to the number of heat units supplied, instead of by volume. The proposals of the Fuel Research Board were made in a Report to the Board of Trade dated January 29 last, and have since been modified somewhat at a Conference on Gas Standards, held on the 28th ult. The present

position of the matter was explained by Sir George Beilby, the Director of Fuel Research, to a gathering of Press representatives on Friday last, and from this explanation we gather that under the new Bill the consumer will be charged for the potential thermal units supplied to him, and that the quantity chargeable will be calculated by multiplying the number of cubic feet registered by the consumer's meter by the declared gross calorific value of the gas per cubic foot. The heat unit used in charging is to be 100,000 British thermal units, and it will probably be known as a "Therm." To check the quality of the gas supplied, its calorific value will be continuously measured and recorded by a standard type of recording calorimeter, which must be passed by the London Gas Referees, who will also prescribe the method of installing, using and checking it. We illustrated and described the Simmance recording gas calorimeter, which will probably be used for this purpose, on page 304 of our last volume. The gas undertaking, we understand, will declare the calorific value of the gas it intends to supply and will have to adjust, and if necessary replace gratis, the burners in the consumers' appliances to enable the gas supplied to be burned safely and efficiently. Afterwards, the gas supplied must be maintained at the declared calorific value, which may not be altered without giving notice to the consumers and making the necessary re-adjustments to their burners. The only other restrictions proposed as to the quality of the gas supplied are that it must be free from sulphuretted hydrogen, and must not contain more than 20 per cent. of inert constituents for the first two years after the Act comes into operation. For the two following years the inert constituents must not exceed 18 per cent., and, after that period, must not exceed 15 per cent. As far as we are aware, no restrictions are made as to the nature of the inert constituents. Some regulation of this matter, we think, might be desirable from the consumers' standpoint, since the presence of $CO_2$ has the effect of lowering the flame temperature. Two gases of the same calorific value would give very different results in incandescent lighting if the inert constituents of one were nitrogen and of the other $CO_2$. The only other question considered is that of pressure, and this, within a period of five years, will have to be kept so that in mains or service pipes of 2 in. diam. and upwards, the pressure is not less than 2 in. of water under normal conditions of supply and equipment. The main point, of course, is that if the Bill becomes law, the consumer will pay for the potential heat units he receives instead of for a certain number of cubic feet, the utility of which is not specified. It by no means follows that the consumers' bills will be reduced by the change, although this may follow as a result of more efficient working at the gas works, but the new arrangement will certainly enable a more reasonable comparison to be made between the charges for gas in different districts. In conclusion, it is perhaps hardly necessary to point out that the accuracy of the consumers' account will still depend upon the correct working of his meter.

Middlesbrough Pig-Iron Shipments.—The latest statement issued by Messrs. William Jacks and Co., 5, East India Avenue, E.C., shows that the shipments of pig-iron from Middlesbrough, including Skinningrove, were, in October, 2,250 tons coastwise and 18,291 tons foreign—total, 20,541 tons—as compared with 21,893 tons in September last, 29,092 tons in October, 1918, and 29,412 tons in October, 1917.

The Technical Inspection Association.—An interesting paper was read at the Society of Arts on Friday evening, the 7th inst., before this association, by Professor Baly, C.B.E., F.R.S. (of the University of Liverpool), on the subject of "The Spectroscope in the Science of To-day," the chair being occupied by the president of the association, Mr. A. H. Collinson, C.B.E., M.Inst.C.E. Professor Baly dwelt upon the extreme importance of the spectroscope in all research work, giving instances of its extended use by three independent groups of scientific men, namely, astronomers, chemists and physicists, but the line of demarcation between these respective groups was so defined that very little information as to the work done by any one group was known to either of the others. Professor Baly urged the importance of the extended use of the spectroscope in all branches of scientific investigation, and he believed the time was approaching when it would be in daily use by the commercial exponents of applied science, as much as by those working in the realms of pure science.

## THE MOTOR CAR SHOW AT OLYMPIA.

In our present number, as in our issues of the last two weeks, we illustrate and describe separately some of the most notable cars exhibited at the show at Olympia, while in our leading article on page 655 we deal generally with the progress of motor-car design. We now propose to continue our review of certain interesting details in car construction as shown by the exhibits at Olympia.

### Springing.

Of those details which have the greatest influence on the comfort of the passenger, springing is perhaps the most important. It is a subject full of difficulties for it covers attempts to deal with the whole range of vibrations and oscillations that can be communicated to the occupants of the seats. The locomotive engineer has been forced to consider the problem in all seriousness, because of the magnitude of the forces, the difficulty of accurate balancing and the damage that may be caused to the permanent way on which the locomotive runs. He divides his troubles into three main classes, pitching, rolling and "nosing around," corresponding to movements of oscillation about the two horizontal axes and the vertical axis respectively. The locomotive runs on a track giving an unequal resistance at regular intervals, and this produces bad effects at certain critical speeds for which the data are available. The automobile engineer has to deal with a much more difficult problem. His vehicle is often run at speeds approaching those of the railway train, but over a surface which is vastly inferior to that afforded by the permanent way. The road surface may be of set-paving or *pavé*, the rounded tops of which produce a rapid vibration that can be minimised by the use of some of the many anti-vibrator devices consisting of stiff helical springs of short period, interposed directly or indirectly between the main springs and the chassis. The surface frequently comprises long stretches of water-bound road, from which the binding material has been displaced, with the result that successive pot-holes have formed along the lines of maximum traffic, and these pot-holes produce a difficulty entirely their own. It is well known that apart from greasiness of surface side-slip can occur on a road that has been tarred or on one covered with wet leaves—as much to be dreaded by the chauffeur as by the locomotive driver. It can happen on deep dust at a bend in the road, and it can be caused by a succession of pot-holes. The periodic loss of touch with the road surface under these conditions allows the velocity of the wheel to increase so that at the times of making contact it actually slips, increasing the damage to the road, and at the same time losing its lateral adhesion. This is a difficulty only partially overcome by anti-vibrator springs, for the line of pot-holes is generally more pronounced on one side of the road than on the other; it is also dependent on the ratio of the spring-supported mass of the chassis and car body to the tyre-supported wheels and back axle.

A device designed to mitigate this trouble should therefore be capable of adjustment to correspond to variation in this ratio, and it should act in such manner as to keep the wheels on the road independently of the main springing, the slower periodicity of which is ineffective for the purpose. The anti-rolling device of Messrs. D. Napier and Son, Limited, of Acton, shown in Figs. 1 to 4, on page 659, has been specially designed to attain this object. The head of the torque tube near the gear-box carries integral with it two lugs A, to each of which is attached, by a pin-joint or trunnion B, a push-rod acting on a short, stiff, helical spring carried in a box C, secured by pivot pins D to the casing, and inclined at 60 deg. to the horizontal. The spring boxes are carried by the casing which is hung on spherical trunnions from the cross member of the frame to allow for sideway movement of the back wheels, and for change of position due to the give of the rear road springs. Any pot-hole in the road allowing greater depression of one of the back wheels than of the other, permits the compression of the helical spring on the opposite side of the torque tube. This helical spring comes into action and accelerates the downward movement of that road wheel by rotating the torque tube about its axis. In other words, it is the helical spring on that side of the car on which the main road spring is compressed that effects the required depression. The springs in the boxes can be varied for strength, so that the combination best suited to the weight of body and to the other conditions can be obtained. The device also minimises the rolling action that occurs when taking a corner.

Another new type of springing is that adopted by the C.A.R. (Cosmos Air-cooled Radial) car produced by the Cosmos Engineering Company, Limited, of Fishponds, Bristol. This is the A.F.S. (anti-friction suspension) patent suspension which consists of a bell crank attachment carried at each side of the back frame and attached to the axle bearings. These bell cranks transmit the vertical load to two opposed horizontal helical springs, the common abutment of which is secured in the centre of the frame. The back axle and propeller shaft casing are converted into a very rigid triangular frame by means of truss-rods on each side, and it is suspended by its apex, a spherical coupling, at the back of the gear-box. At the front of the car the same spring suspension is used, and it has been necessary to anchor the front axle ends by means of thin spring-steel radius rods. Experience with helical springs on locomotives has not been altogether favourable, but those who have tried the A.F.S. suspension state that for car work it has proved its good qualities in eliminating vibration.

The necessity for providing lubrication in the springs is shown on many cars by the fitting of leather gaiters; this accessory is very inexpensive, and if correctly made and fitted it eliminates a great source of discomfort and prevents the production of a squeaking noise often difficult to locate.

### Engines.

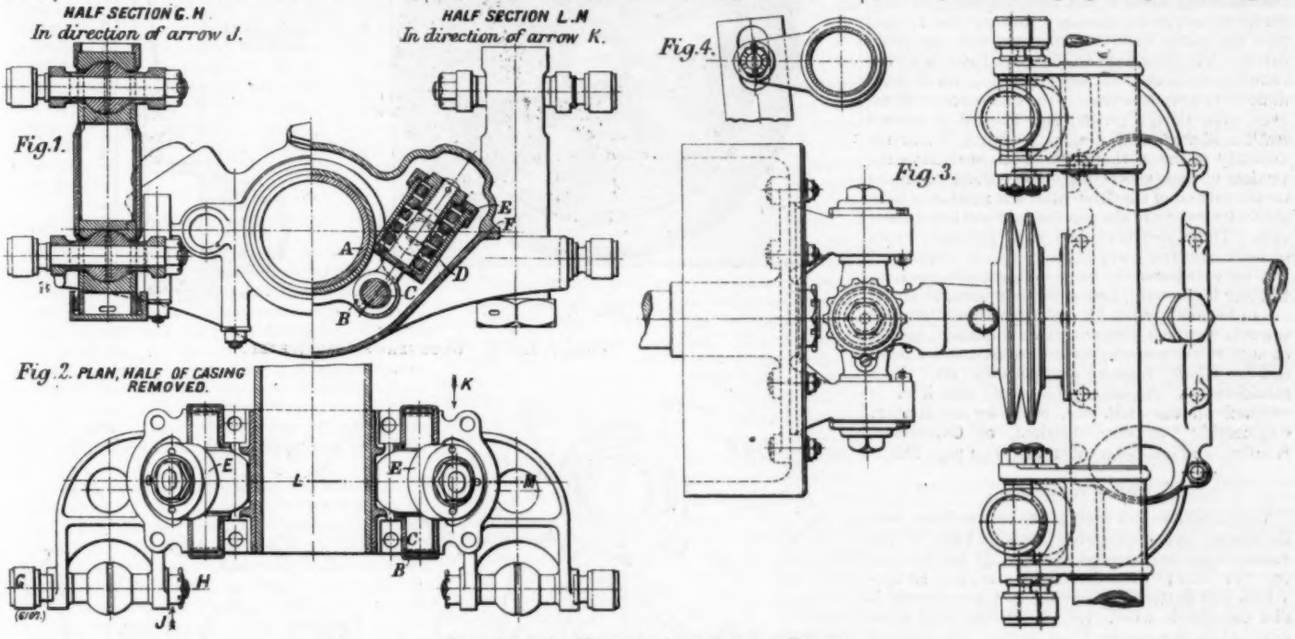
In our previous article (see page 622 of our last issue) we alluded to the changes in engine design; a glance at the motors shown this year, several of which we have illustrated separately, reveals almost complete absence of evidence of valves, valve gear or moving parts. Everything that moves is enclosed in many of the models, and the tendency appears to be to make this change complete and thorough, so that the motive parts of the car of the future will be as well concealed as those of a gun or of a watch. At the same time, the makers are taking care that while covering up the parts and excluding dust, they are providing the means for as easy and rapid access as in the productions mentioned. Among reasons for adopting the detachable head for cylinders is the much easier coring of the head casting, giving greater facility for securing equal cubical content of the compression space and therefore greater uniformity in the power developed in each of the cylinders.

The statistics compiled by our contemporary *The Autocar* show that of 271 cars exhibited, representative of British, French, American, Italian and other makes, 67 per cent. have a four-cylinder engine, and that the order of popularity of the others is 20 per cent. of six-cylinder and about 6 per cent. each of two and eight-cylinders. Of these engines, 83 per cent. are fitted with electric self-starters, and 2·5 per cent. with mechanical starters. The ignition fitted is, in 84 per cent., of the magneto type and in 10·5 per cent. it is by battery and coil. The position of the radiator is in front of the engine in more than 95 per cent. of the cars. In very few of the motors is air cooling adopted, and these are generally for low-power cars approximating to the light car and cycle type.

### Brakes.

The tendency to abolish the brake on the propeller shaft and to apply the brakes to drums carried on the road wheels is growing, but slowly. Some few cars were fitted with both brakes on the back wheels quite early in the century; in the very early instances these were external and found liable to slip owing to grease working on to the surfaces, or to grind away rapidly in dry weather and require frequent adjustment and renewal. The propeller-shaft brake became popular; it was generally attached to the frequently-used pedal rather than to the less rapidly worked handle at the side of the car. It was much more efficient as a means of

stopping the car than the brakes then fitted to the wheel drums. For this there were two reasons: Firstly, that the product of shoe-surface by velocity was much greater than could be provided with wheel drums of a size that did not then appear disproportionate (the hand brake being considered only as an emergency appliance and therefore cut down to the minimum of size). Secondly, because any frictional losses in the cardan joint, propeller shaft bearings and the bevel or other transmission, all acted to increase its efficiency in producing negative acceleration. On the other hand a propeller-shaft brake, unless specially designed to avoid "fierceness" is apt to chatter owing to the torsional spring of the propeller shaft itself and of the floating axles. This causes great increase in the stresses in the shafts and on the bevel gears, or whatever transmission is used. If the makers of cars were to take the propeller shaft brake proportions and translate them—in terms of the product of surface by velocity—to the back wheel drums, they would arrive at a solution which would differ considerably from most of the practice to be seen to-day. Two cars are remarkable in this respect; one, the Delage, a French car of very high quality, adopts an arrangement of combined front and rear wheel brakes, all balanced and operated from the foot pedal, the hand lever being retained to operate the other back wheel brakes. The other example is the Armstrong-Siddeley car, which takes advantage of the disk wheel to fit inside the space it affords a drum of really ample dimensions. In the case of the expanding shoe brake there is, moreover, considerable variation in practice, chiefly in the form of the cam; many car builders make the cam of lozenge shape, others of a shape parallel with two large radii, but both of these give varying effective leverage as the range varies. The best method for making these has been pointed out by Mr. O. D. North at a discussion on live axles for commercial vehicles,* in which the speaker showed that it was possible so to design the cam that the lever started to work 30 deg. behind the vertical and had an equally useful movement for more than 60 deg. We give in Fig. 5, below, an illustration of this form of brake, designed by Messrs. Dennis Brothers, as it does not appear to be generally known.




FIGS. 1 TO 4. NAPIER'S ANTI-ROLLING DEVICE.

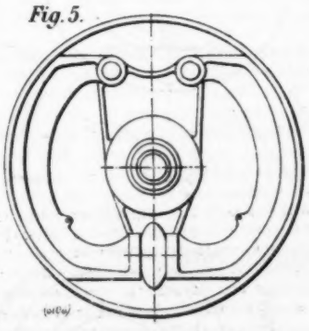



FIG. 5. DENNIS BROTHERS' BRAKE ARRANGEMENT.

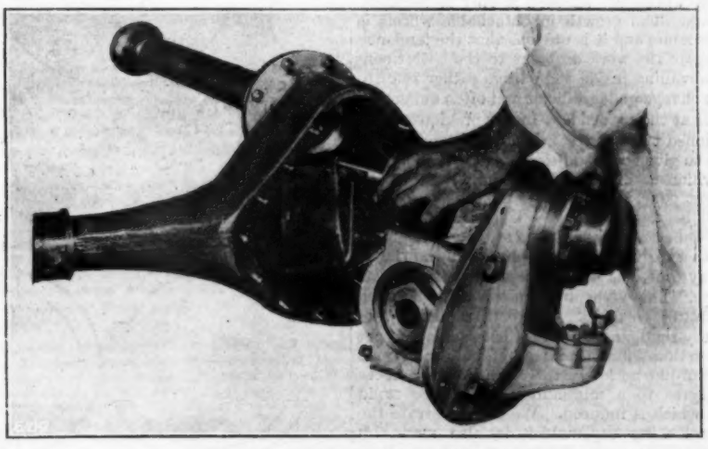


FIG. 6. BACK-AXLE ARRANGEMENT OF "H. E." CAR.

### CLUTCHES AND GEAR-BOXES.

The cone clutch appears to hold its own for popularity, heading the list with 45 per cent.; the disc accounts for 28 per cent., and the multiple plate for 24 per cent., while the friction drives amount to less than 2 per cent. It is of interest to note that the Palladium car, a description of which we give on another page, has adopted the integrating disk, which has been used on the G.W.K. car with considerable success for some years. It is now being adopted by another firm, and the arrangement designed for its manipulation by lever and quadrant is very well considered.

The practice in number of gear-box speeds, apart from the reverse, is by no means stabilised. Of the 271 cars over 51 per cent. have four speeds, 46 per cent. have three speeds and the remainder two only. There appears to be no sort of rule to govern the selection of the number of speeds. A search through the published tables fails to reveal any connection between this number and the price, the power or the proportions of the engine. To some extent the selection is national, for the French and Italian makers prefer four speeds, whereas the Americans prefer three. The matter is really one that can be settled by a diagram, and by comparing the overlap of the car speeds obtained with the different gear ratios for the range of engine revolutions corresponding to the nearly straight line or working part of the torque diagram. The large range of speed for nearly uniform torque given by modern engines should render the fourth speed quite unnecessary, and its elimination would save much complication in the gear-box and control mechanism. We may, therefore, expect to find the popularity of the four-speed gear-box greatly diminished in the future.

### FINAL DRIVE.

Again referring to the 271 cars, the final drive that is at present most popular with manufacturers is the straight bevel. This system leads with nearly 63 per cent.; it is followed with 20·5 per cent. of spiral or other non-straight bevels, and the next in favour is the worm and worm wheel, which accounts for 13 per cent. It is probable that when more of the American gear cutters are available fo

* Proc. E. Inst. Automobile Engineers, vol. x, pages 210 and 211.

producing the spiral bevel, this type will come into greater use. It is a well-established fact that the greatest sources of noise in the transmission mechanism are those due to minute cyclical changes of angular velocity in the shafts; of these, the wheels in the gear-box and the back-axle bevels are the worst offenders. Noise has been eliminated in the engine timing gears by the use of silent chain drives and particularly by helical gear transmission, together with the more complete enclosing of all these parts. In the gear-box the spur wheels have been the subject of great solicitude; they have been cut on developing machines, case-hardened with every precaution, set true to the teeth in the grinding machine and finished to bore and face so accurately that gear-box noise is fast disappearing. It may, therefore, never be necessary to adopt for touring cars the motor omnibus gear-box, with its chain drives. The back axle on the other hand, is a very complex unit, and the bevel wheel is much more difficult to keep true than is the spur wheel. Moreover, even though ground and finished to perfect truth it is, with most designs, a matter of extreme difficulty to ensure that both wheels shall have the vertices of their generating cones coincident on the rotational axis of the differential box; either or both may fall away from the point of intersection of these axes. Those designers who have produced types of back axle from which the complete component can be withdrawn in its actual gearing position, whether it be worm, helical bevel or straight bevel, are to be commended for making material advance towards the final elimination of a trouble, serious enough at the manufacturers' works, but far more serious where repairs or renewals are under consideration. An arrangement of this kind is adopted on the H.E. car, made by the Herbert Engineering Company, Limited, of Caversham, Reading, and is illustrated in Fig. 6 on page 659.

### Road Wheels.

The statistics show that, of the cars we have been discussing, detachable steel spoke wheels of the Sankey type are adopted in about 35 per cent. of the 271 cars; wire detachables of the Rudge-Whitworth pattern account for 22 per cent., steel-disc detachable wheels for 18 per cent. and wood detachables for nearly 7 per cent.; the total of detachables thus being 82 per cent. Wood non-detachable wheels are adopted in only 12 per cent. of the cars. The growth in detachable wheels is very noticeable, and it is obvious that the tendency is to relegate the work on tyres to the better conditions prevailing inside the garage rather than to effect the change under difficult and often dangerous conditions at the road side. In our previous notice we mentioned the Goodyear disc wheel, and we are now able to give some additional particulars of this model, which is illustrated in Figs. 7 and 8, on the present page.

As will be seen, the wheel is in the form of a corrugated disc. An advantage of the arrangement is that the tyre valve can be placed in the rim in such a way that it is not necessary to cut any part of the disc. This gives uniform strength all round and facilitates cleaning. The construction is, of course, very rigid, and the wheel is less likely to get out of truth than a flat disc design. It is also claimed that the fan-like action of the corrugations reduces heat in tyres to a minimum through the rapid radiation which is induced. We also illustrate the Goodyear locking cap, which is also made by Messrs. W. Goodyear and Sons, of Dudley. It is shown in Figs. 9 to 14, annexed. The arrangement is best seen in Fig. 9, which shows the ratchet end of the hub shell with the cap removed, and, above, the cap reversed to show the internal mechanism. Details of the cap parts are shown in Figs. 11 to 14. The remaining illustration, Fig. 10, shows the cap in position on the wheel, with the spanner in place for removing or screwing up the wheel. Turning the spanner to the left draws the wheel from the axle and, turning it to the right tightens it. The spanner carries a cam with a lever, shown in the upper part of Fig. 10. When in the position indicated in this figure, the cam depresses the upper bridge-piece, which is shown at D, in Fig. 11, and presses the guide pins through the cap, as shown at 1 and 2 in Fig. 10. This prevents the spanner being taken off as long as the locks are not in engagement. One of the guide pins is shown in detail in Fig. 13. When the cam is turned at right angles the bridge-piece rises and locks the wheel by means of the ratchet catching on the bridge-pieces, one of which is marked A, in Fig. 11. The spanner can then be removed.

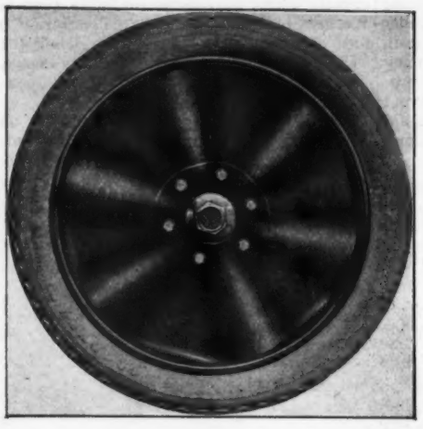
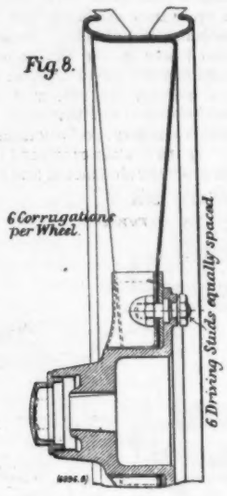
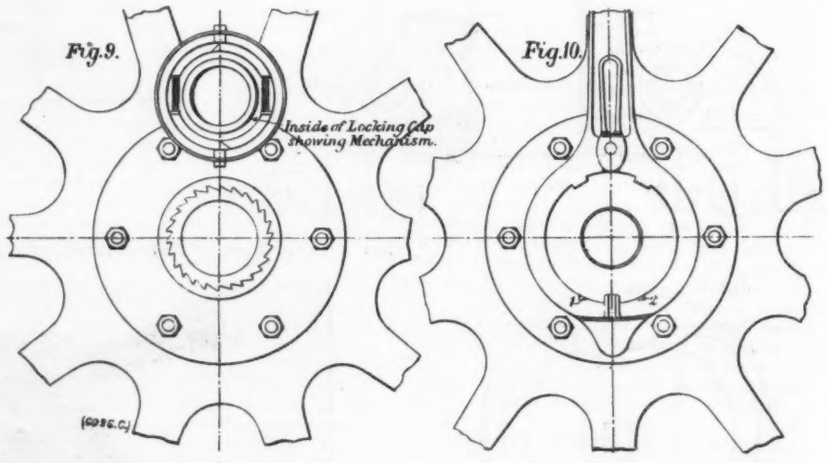
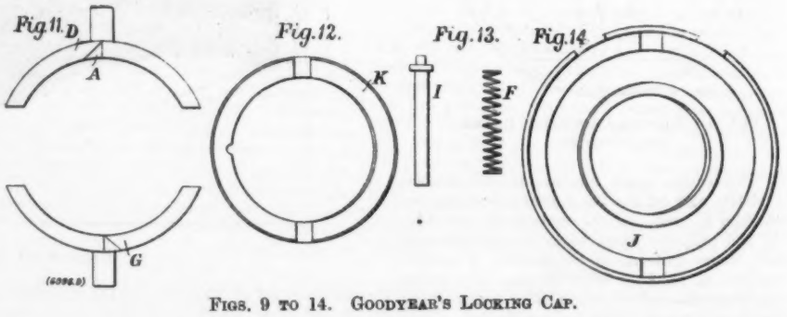


Fig. 7.




Figs. 7 and 8. Goodyear's Disc Wheel.




Figs. 9 to 14. Goodyear's Locking Cap.

### Details.

One of the details that has been the source of unlimited worry, and even of danger, in the past, is the petrol cock. One firm of accessory makers, Benton and Stone, Limited, of Birmingham, have produced models of petrol cocks of entirely original design. They do not depend on a cone plug, but the surface is a disc with ports communicating through the upper chambered part of the cover. The seating is a cork disc, and the construction is as good as the design. In a further development of this type of fitting the makers have added a combination lock device in which a number of pins project by spring pressure round the head of the cock; it is necessary to push two or more of these home in proper combination with the fingers of one hand before the plug can be rotated by means of the handle. This should be a valuable device for preventing car stealing, as a car will not run far on the small amount of petrol remaining in the carburettor after the supply has been shut off.

A car lock of ingenious design is that in which a clip secures the device to the steering column, and two bent arms pivoted to it can be turned up

over the spokes of the steering wheel and locked in place; a key releases the pin securing the clips, and permits its withdrawal.

One of the French cars has a very neatly-arranged thermometer carried in the radiator-filling cap, the coloured liquid of the column being clearly visible from the driver's seat.

An improvement in speedometer drives is shown in the 11 h.p. Beardmore car produced by the firm of William Beardmore & Co., Limited. In this arrangement the constantly running wheel in the gear-box is used to obtain a rotation of the flexible shaft proportional to that of the road wheels.

Improvements have been made in the engagement of self-starters. The C.A.V. gear made by Messrs. C. A. Vandervell and Co., Limited, of Acton, as exhibited shows a marked contrast with the usual method, a slight depression of the lever or button causing the pinion to engage with the flywheel gear at a very slow speed, and full depression giving the proper speed for starting the engine. We hope to deal with the whole subject of self-starters more fully later, in an article devoted to those shown at the exhibition.

### Coach Work Accessories.

Generally speaking the metal work of coach bodies is far inferior to the woodwork; it is therefore of interest to examine the best practice as shown in the fine limousine-landaulet built by the Cunard Motor and Carriage Company, Limited, and exhibited by Messrs. D. Napier and Son, Limited, of Acton. In this body it would seem as though all imaginable precautions had been taken for guarding against theft, the production of noise or rattle, both when new and after long use, and for facilitating communication with the driver.

An ordinary lever lock—or, as the coach builder would term it, a "private lock"—is fitted above the slam lock on the door pillar, and takes into the shut of the door. The door can thus be locked with a small key such as can be carried in the waistcoat pocket. The door itself beds on three adjustable fibre striking-plates at the top, bottom and opposite the slam lock, so that any shake that may develop can be taken up. The lock itself is of the double striking-plate pattern, which gives a safety device to prevent the door from swinging open if imperfectly closed.

The window glasses of the quarters and doors are fitted with a spring lift to balance much of the weight, and a narrow steel frame, with thumb-piece, at the top only, to prevent fracture of the glass when the door is slammed, and to enable the glass to be pushed right up or pulled down with the fingers. The windows in front behind the driver are of triplex plate glass, sliding horizontally, and fitted with vertical steel frames and thumb-pieces at the outer sides only. Anti-vibration rubber pads, each actuated by a thumbscrew passing through a sunk plate, enables sufficient pressure to be applied to the window glasses to prevent any rattling. The wind-screen glasses are of similar pattern and fitted with sector adjustment. The roof of the body is of leather, lined with cloth to damp out noise.

On the off, or right-hand side, of the car a new fitting is provided for communicating with the driver, consisting of a "dictagraph" attachment. There are two pushes and a receiver fitted near the door pillar. The lower white push, when pressed, sounds a buzzer and attracts the attention of the driver to his speaking tube. On pressing the upper or black push the conversation in the car can be heard by the driver, without raising the voice, but only for so long as the push is kept depressed.

The folding seats are also much in advance of the usual fitting. Each of these is fitted with sunk pivots having their axes below the floor level and near the centre of the car; when closed they fold down against the front of the body. When raised a notched lug on the corner of the seat diagonally opposite to the hinged leg engages with another notched lug carried on the door pillar, into which it locks, so that each seat has two rigid supports diagonally opposite each other, and a much stiffer form of construction than usual is provided.

The door hinges, of the Soss patent form, are of ingenious design. The hinge-box sunk in the corner-pillar of the door carries two pins; a projecting tail on the hinge plate secured to the door is cut through horizontally with a number of parallel slots in which two sets of links engage, the inner link taking on to the back pin of the box is straight, and the outer link, taking on to the other pin, emerges partially out of the cavity, and is cranked so as to follow the curve of the hinge plate. The result of the double link connection is that the door rotates about the virtual centre at the intersection of the lines joining the centres of the two respective links, and this throws the door clear of the shut in the earlier part of the movement, and clear of the doorway in the later movement. It thus assists the striking-plates in maintaining perfect contact between the door and the pillars.

### Foreign Cars.

It is difficult, and would be misleading to compare the foreign cars exhibited with the British cars taken as a whole, for of course the cars of foreign origin at Olympia are those of the most popular and most successful makes in their respective countries. They are generally of makes that were already known in this country before the war, and though they have undergone change, the differences in Continental practice are in general smaller than in our own or the American models. The French and Italian chassis show great excellence of workmanship, but less tendency to adopt bulk manufacturing methods, whereas the Americans go far beyond ourselves in this direction. The small car of foreign build is but little in evidence, but the powerful cars compete favourably with our own, import duties notwithstanding. Probably the full effect of the introduction of mass production methods into this country, following their adoption in America, will not be reflected in Continental practice for the next two years. But it must be remembered that the French and Italians have many well-equipped and excellently-managed factories, and that faith has been lost in the idea that the British workman does more in a day than the Frenchman or the Italian. There have been too many opportunities to compare rates of working and prices of finished munitions during the war. Production alone, and not protection, can secure the markets of the world in the future for the motor industry of Great Britain.

## CATALOGUES.

*Electric Winding Engines.*—Three catalogue leaves from the British Westinghouse Company, Limited, Trafford-park, Manchester, contain lists of these engines from 75 h.p. to 3,700 h.p., stating the firm to which each engine was supplied (home and overseas) and leading particulars of the motor, current supply, capacity and system of gearing.

*Boiler Stay Bolts.*—A special "longstrand" mild steel for staybolts, tie rods, shackles, draw gear, &c., is described as to its qualities in a catalogue from Messrs. Brown, Bayley's Steel Works, Limited, Sheffield. Various test results are quoted, and the relative merits of copper, wrought iron and this special steel are discussed as to their fitness for boiler stays. The steel has been used for this purpose for about twenty years by some British railway companies. It is supplied as either solid or hollow rods.

*Aircraft.*—The Blackburn Aeroplane and Motor Company, Limited, Leeds, Hull and London, has issued an interesting illustrated booklet in celebration of their tenth year of existence, and in record of their war work. The text is written by Sir John Foster Fraser, and is of general, rather than technical, interest. The company made sea and air planes of quite a range of types: Single-seat fighting scouts, torpedo planes, coast and submarine patrol planes, three-seat, long-range bombing planes, passenger and goods carriers, and a single-seat pleasure flying boat. The record is one of the finest in the war, and the firm will continue their work.

*Drop-Forging Machinery.*—It is evident that British engineers are determined to look well to the drop-forging industry in future. A catalogue from Messrs. Bretts Patent Lifter Company, Limited, Coventry, shows a very fine series of plants which they have made and installed for firms in all parts of the country. One illustration shows 25 steam-driven drop-hammers erected in line with tups of 5 cwt. to 3 tons weight. Steam, compressed air, electric motors and ordinary belt drive are provided for, including arrangements for raising steam from the waste heat of the metal-heating furnaces. This firm specialises in drop-forging equipment, including coke and oil furnaces, clipping and other presses, &c., as well as the making of the forging plants with lifting gear.

*Aerial Cableways.*—A catalogue from Messrs. John M. Henderson and Co., Aberdeen, shows illustrations of a very large number of ropeways for hoisting and transporting, mostly of a powerful type, but also examples of simple appliances for light transport inside of buildings. All are actual plants made and erected by the firm. Both fixed and travelling cables are represented; also steam and electric drives. The most striking are the special services erected for building long viaducts, excavating huge docks and working out granite quarries. The designs show great ingenuity in coping with difficult situations and a wholesome regard for strength and hard-working qualities. The firm also makes all machinery, gear and accessories required to complete an installation.

*The City of Cork.*—The Cork Chamber of Commerce and Shipping has issued the first edition of a book giving an account of the trades and commerce of the city and neighbourhood. There are some interesting chapters on municipal and industrial history and local educational institutions, followed by an account of the local agricultural, mining, manufacturing and trading resources. There is a fair amount of local engineering, shipbuilding and ship-repairing, and the American firm of Messrs. Henry Ford and Son are establishing very extensive automobile works. Evidently Cork is in a flourishing condition. The book extends to 260 pages, quarto, with many excellent illustrations and several maps. Its general effect is marred by interleaving advertisements—a fault to be found in some English publications of the same kind.

*Oil Engines.*—A fine series of vertical two-cycle oil engines are shown in a catalogue issued by Messrs. Robey and Co., Limited, Lincoln. The fuel is crude oil, Admiralty residual oil, or the ordinary lamp oils. There are 10 single-cylinder engines ranging from 6 brake horse-power to 50 brake horse-power; eight two-cylinder engines, 24 brake horse-power to 100 brake horse-power; one three-cylinder engine, 150 brake horse-power; and one four-cylinder engine, 200 brake horse-power. In addition there is a series of eight single oil engines of 4 brake horse-power to 30 brake horse-power, mounted complete on four wheels with broad metal tyres. The regulation is by a centrifugal governor, which acts by varying the stroke of the eccentric from which the fuel pump is driven, lessening the supply of fuel when the set speed is exceeded. All these engines are made in quantities to standards and of the highest class of material and workmanship. Fixed engines are shown with pumps or dynamos on one baseplate.

*Small Marine Engines.*—Messrs. John I. Thornycroft and Co., Limited, 10, Grosvenor Place, S.W. 1, send a new catalogue of the small marine paraffin and petrol engines, made at their Basingstoke works. There are five paraffin engines which start on petrol or on paraffin by lamp, or may be run on petrol only; and five corresponding engines to work on petrol only. Engines with the same number and bore of cylinders, same revolutions per minute and same total weight (installed) give about one-fifth more power on petrol than on paraffin. The engines can also be adapted for alcohol. A 30-h.p. paraffin motor (or 36 h.p. petrol) has a total installed weight of 24 cwt., which, of course, will be greater if an unusually long shaft or extra tank capacity are required. A comparison may also be made between normal and specially light engines, both petrol and with reversing gear, the light engine figures being given in parenthesis: Number of cylinders 6 (6), diameter 6 in. (4 in.), stroke 8 in. (7 in.), revolutions per minute 700 (1,300), total installed weight 59 (19), cwt., h.p. 80 (70), fuel consumption 5 gallons (5½ gallons) per hour. The foregoing figures, which give a good general basis of comparison, are the standard practice of a firm of the first rank equally famous for the most substantial and economical commercial work and for the highest class of high-speed work in small marine boats; and there are no foreign made installations which would nearly compare on all points. The catalogue contains all the necessary detail of weights, dimensions, &c., in both inches and metres. French and Spanish editions are in preparation.

General Smuts on the South African Coal Industry.—Speaking recently at Victoria West, the Prime Minister, General Smuts, made another eloquent appeal to South Africa to make a fresh start, says *The South African Mining and Engineering Journal*. He stated that South Africa was undoubtedly the greatest mining country in the world. "You have more minerals here," he added, "you have a greater wealth of mines here than you will find anywhere else. Our coal is one of our greatest assets. But whoever thinks of that? The other day I had a conversation with a gentleman who came here in connection with a scheme for the electrification of our railways. Our railways can be run much cheaper by electricity than by steam, and the gentleman who has come out in connection with the matter is an expert with a world-wide fame. I discussed matters with him, and we talked about our South African coal, which made him remark that there was nothing in the world like our country. 'South Africa's potentialities as regards coal,' he said, 'are immense. You have one continuous coalfield here and in Rhodesia which will not be exhausted for a thousand years.' In view of the fact that coal is one of the articles of which the human race has the greatest need, you can appreciate the possibilities and potentialities of a country like ours. We have enormous quantities here of the cheapest coal in the world. In olden days people only thought of the diamonds and gold which South Africa produces, but our diamonds and our gold must go as time passes, yet there are other resources which will be far more valuable in the long run."

## PHYSICAL SOCIETY OF LONDON.

At the meeting of the Physical Society of London, held on October 24, at the Imperial College of Science, Professor C. H. Lees, F.R.S., president, in the chair, a paper, entitled "*The Effect of Pressure and Temperature on a Meter for Measuring the Rate of Flow of a Gas*," was read by Dr. N. W. McLachlan. The following is an abstract of the paper:—

The theory of an instrument for measuring the rate of flow of a gas is outlined, the effects of variation in the temperature and pressure of the gas being taken into consideration. This theory is tested experimentally for pressures varying from 1,250 mm. to 250 mm. Hg., and for temperatures from 10 deg. to 100 deg. C. It is found to be fairly accurate. The results are applied to the measurement of the rate of flow of gas on an aeroplane in the upper atmosphere, where a reduction in temperature and pressure is encountered. It is shown that the instrument reading for a certain N.T.P. volume of gas depends on the altitude, but that this volume can be obtained by using a correction factor.

*Discussion.*—Mr. C. C. Paterson asked if the results depended on the structure of the meter, since the paper only referred to one type.

Dr. A. Griffiths suggested that some automatic method of compensating the error would be advantageous as a direct reading instrument was always desirable.

The Author, in reply, said that compensating devices were under investigation when the war came to an end. The pressure effect could be compensated by using an aneroid control to vary the area of the vane in use, but he did not see how the temperature effect could be easily corrected. As regards the structure of the meter, the diameter of the nozzle was about 3/32nds of an inch, and the rectangular vane was mounted very similarly to the moving parts of a moving coil ammeter. Either electro-magnetic damping or, for laboratory purposes, ordinary fluid damping could be used.

A paper on "*A Cheap and Simple Microbalance*," was read by Captain J. H. Shaxby. The following is an abstract: The instrument, devised for bacteriological use, had to be cheap and moderately robust. It consists of a long horizontal fibre joining the lower ends of two vertical beams, each pivoted very little above its centre of mass. A small weight acting at the middle of the fibre thus causes a considerable depression. This is read off by arranging a slider on a vertical millimetre scale about 2 ft. in front, so that the middle of the fibre and a second short fibre placed just behind it are in line with a "peephole" on the slider. Adjustment is provided for quickly and largely altering the sensitiveness. The deflections are converted to masses by the use of calibrating weights. The apparatus is built up from a "Meccano" set.

*Discussion.*—Mr. C. C. Paterson thought the instrument would have many useful applications. Had the author considered the possibility of making it a null method? A simple electromagnetic arrangement could be employed for the purpose.

Professor Bragg suggested a simpler null method, which consisted in the addition of weights to attachments to the side pieces. The arrangement could be such that quite considerable weights had to be added to produce a slight disturbance of the balance.

Mr. T. Smith asked if the author had tried reading the position of the fibre against a thick thread mounted parallel to it, instead of the inclined thread he had described. If the thick thread were brightly illuminated, and the fibre adjusted so that it appeared to bisect the width of the thread a very accurate setting would result.

Dr. D. Owen asked for the sensibility of the instrument shown at the meeting, and Mr. F. J. Harlow asked the form of the calibration curve.

Professor Lees said the instrument reminded him of a well-known text-book method for measuring small horizontal forces, in which the force produced a small horizontal displacement of a weight suspended by a long thread. If two such suspended weights were connected by a horizontal fibre to which small loads could be attached, a micro-balance somewhat similar to Mr. Shaxby's would be obtained.

The Author, in reply, said Mr. Paterson's suggestion was interesting. He had made some attempts to convert the instrument into a null one with a magnetic control below the load. He had also tried Professor Bragg's suggestion, by mounting weights on short horizontal arms near the fulcrums of the vertical rods. As regards sensitivity, readings could be repeated to about 1/500th of the maximum load for which the balance was adjusted. The calibration curve was nearly a straight line.

A paper on "*The Resolution of a Curve into a Number of Exponential Components*," was read by Mr. J. W. T. Walsh, M.A., M.Sc. The paper gave a method for the resolution of a curve of the compound exponential form $B = \sum_{1}^{n} a_{1s} e^{-\lambda_1 t}$ into its components, the values of $a$ and $\lambda$ for the $n$ different exponential terms being found from $2n$ values of $B$ equidistant along the axis of $t$. A method is also given for finding the most probable values of these constants from any number ($> 2n$) of observed values of $B$ taken at irregular intervals of $t$.

*Discussion.*—Mr. T. Smith said the crux of the matter appeared to lie in the proper choice of the number of components, and this was not touched on in the paper. It was possible to come to a decision provided the observations covered a sufficiently long period. Suppose one felt justified in taking $n$ terms, but was uncertain whether or not to go to $n + 1$, a comparison of the outstanding errors when first $n$ and then $n + 1$ terms were taken would reveal whether there was any advantage in introducing the extra one.

Professor Bragg asked whether in the event of uncertainty as to taking $n$ or $n + 1$ it made much difference which was adopted. Did all the old $\lambda$'s change and another one of comparable magnitude come on?

Mr. T. Smith said the new $\lambda$ might well be quite large, and Mr. E. H. Rayner pointed out that it depended on the relative values of $a$, and $\lambda$ whether there would be much difference in taking $n$ or $n + 1$. Professor Lees asked if the method worked when the $a$'s were negative?

The Author, in reply, said that in some curves the value of $n$ was known from a priori considerations; and in some other cases it was sufficient to take enough terms to fit the experimental curve well. The modifications of the $\lambda$'s in taking $n + 1$ instead of $n$ terms was not simple. In ordinary cases all the $\lambda$'s would be varied, and a new one comparable with the others added. The method applied equally to negative $a$'s.

## THE CORROSION OF IRON AND STEEL.

The corrosion of iron and steel and the means of preventing it, a problem the solving of which is quite as important as the economical utilisation of all metalliferous resources, formed the subject of the presidential address which Mr. H. B. Weeks recently delivered before the Barrow Society of Engineers.

In his opening remarks, Mr. Weeks said that the corrosion and pitting of iron and steel was one of the most prolific sources of the worries which attended the duties of every sea-going engineer; this statement was corroborated later on in the course of the meeting by an engineer-commander of the Royal Navy, who added that the boilers, a most vital part in a ship, were a never-ending source of anxiety, one which kept the engineer fully occupied. Fortunately, a process had been devised which Mr. Weeks considered the best from the theoretical and practical standpoints for the protection of metals, especially as applied to boilers, economisers, condensers and other apparatus connected with steam raising; he referred to the Cumberland electrolytic method, a method which seemed to him to be an ideal one for such purposes.

In regard to other applications referred to by the speaker, the process patented by Dr. Angus Smith had proved very successful in preserving underground iron. In this process, coal tar was boiled until all the water, the ammoniacal liquor and the lighter oils were expelled, and the prepared tar was applied to the cast-iron fresh from the mould. This was an ideal process for the protection of water pipes. The latter were heated to 300 deg. F. and were then lowered into the tar heated to the same temperature, and allowed to remain in it until the hot and fluid tar had soaked into the pores of the metal. The process when carried out properly was very efficient, and he knew of no better means of protecting iron and steel from atmospheric corrosion. It should be noted, however, that the means of application were more important than the so-called solution itself; the solution simply applied with a brush was not Dr. Angus Smith's process at all. Mr. Weeks alluded to the occurrence of ship's plates practically corroded through from the inside, except in such places where the cast number had been painted on the plates whilst these were black hot from the rolling mills. In such places, the plates were of their original thickness, and nothing pointed more forcibly to the absolutely ideal way of preserving iron and steel, the heat ensuring the absence of moisture and enabling the paint to more or less permeate the surface pores of the metal. The protecting of the plates on the inside of a ship was quite as important as protecting them on the outside, since the inside may be exposed to the corrosive action of the bilge water rendered more active by a higher temperature in the holds than that prevailing outside, to leakages from cargoes, acids and sulphates from wet coals, electro-negative bodies such as coal dust, scale, &c., all contributing their quota to the corrosion that went on unless means were taken for efficiently protecting the plates from its ravages.

Dealing with the corrosion of mild steel as compared with that of wrought iron, Mr. Weeks said numerous experiments showed that there was a greater tendency to corrosion in sea water in the case of steel than in that of wrought iron, although the fact had been denied over and over again as the result of other investigations. The fact probably was that in the case of a very pure specimen of wrought iron, the corrosion was less than would be the case with a specimen of ordinary mild steel, whilst the corrosion of the latter might very easily be less than that of a very impure specimen of wrought iron The higher percentage of combined carbon and manganese that the steel usually contained appeared to be one cause for the latter corroding more readily than wrought iron which, ordinarily, contained traces of these elements only.

Reverting to the phenomena as they affect boilers, two forms of rusting may be the cause of the pitting of tubes and plates: (*a*) Ordinary corrosion due to the presence of moisture, carbon dioxide and free oxygen which formed ordinary rust, and (*b*) the more local corrosion due to the galvanic action which was set up at such spots and which resulted in uneven pitting and possibly puncturing. Very soft water contained practically no salts in solution, and had therefore nothing to deposit on the boiler plates which were constantly exposed to conditions likely to set up corrosion—the dissolved gases in the presence of water. The author dealt with the *pro essus* of deposit and incrustation formation in the case of feed waters of different qualities, and added that every engineer realised how important it was to prevent boiler corrosion by some means, and the number of compounds guaranteed to meet this was very great, varying from potato peel to complex chemical reagents. Most of these had an injurious effect upon the metal, or else produced a large quantity of loose deposit which in marine tubular boilers continuously working, choked up the spaces between the tubes and made the remedy worse than the disease. For such reasons Professor Lewes had stated that no treatment of sea water in the boilers was practicable; with high pressure tubular marine boilers the feed water must either be condenser water made up to the bulk required with distilled water, or else the condensed water must be made up to the bulk required by sea water that had been specially prepared in an apparatus for the purpose, before it was supplied to the boilers, by heating the sea water under pressure with carbonate of soda and filtering off the precipitated salts before supplying the water to the feed tanks.

Various reagents and processes were reviewed in the address from which we quote, and the influence of heterogeneity in the composition of the material forming the boiler, together with the influence of internal local stresses in the material, was also emphasised.

The fact that pitting was often as pronounced in the economisers as in the boilers confirmed the statement that rusting took place in presence of water and air. It was necessary that some simple means should be at hand for constantly testing the feed water. It should be tested for acidity and alkalinity both in the economisers and boilers, as it did not necessarily follow that it would give the same reaction in both, even at the same time. Lime should be added to the feed water in such a manner that would ensure that some of it was always present in the economiser tubes as well as in the boilers. It was important that the lime should be fresh; it should not have been previously exposed to air or moisture before use. Proper attention had also to be paid to "blowing down" periodically, or the treatment with lime would be rendered futile.

The various theories advanced as to corrosion, the $CO_2$ theory, the electrolytic theory, &c., and the various processes followed in conjunction with these, were enlarged upon by Mr. Weeks. The protection afforded by tinning, galvanising, Sherardising, varnishing and painting was also dealt with in detail.

The address, in short, forms a useful and interesting compendium on the subject of corrosion, and deserves to be widely distributed for the guidance of all engineers who are confronted with the problem.

Industrial League and Council.—A lecture arranged by the Industrial League and Council (incorporating the Industrial Reconstruction Council and the Industrial League) will be held in the Council Chamber of the Guildhall, on Tuesday the 18th inst. The chair will be taken at 4.30 p.m. by the Right Hon. the Lord Mayor, and an address on the "Industrial Outlook" will be delivered by the Right Hon. Sir Auckland Geddes, K.C.B., M.P. Admission is free. No tickets are necessary.

The Housing Problem in France.—Following upon the Housing Congress recently held in France, there has been instituted in Lyons a Permanent Committee of Housing Congresses which will also deal with competitive exhibitions of material and machinery used in house construction. The object of the new body is to develop rational, rapid and economical methods of house-building. A central bureau on construction and housing is to collect all French and foreign documents concerning these subjects. The next Housing Congress will be held at Lyons during the Lyons Spring Fair, in the first fortnight of March, 1920, when the first competitive exhibition of material and machinery will be opened. Manufacturers of the allied nations are invited to take part, and should apply to the Office Central de la Construction et de l'Habitation, Hotel de Ville, Lyon.

The General Electric Company, Limited.—We recently had an opportunity of inspecting the works at Erith formerly owned by Messrs. Fraser and Chalmers, and acquired some time ago by the General Electric Company, Limited, whose head office is at 67, Queen Victoria-street, London, E.C. 4. The Fraser and Chalmers Engineering Works, as they are now called, will continue to work along the same lines as formerly, their main products being steam turbines, turbo blowers and compressors of the Rateau type, conveyors and transporters, mining plant, winding engines, gas-cleaning plant, rolling-mill equipment, &c.; the original staff has been retained with the addition of Mr. E. W. Wilson, who will look after the interests of the new proprietors. The step taken by the General Electric Company has the obvious advantage of rendering them independent of outside concerns when called upon to supply complete turbo generators and electrically-driven machinery. It will also assist the general policy of the firm which, we understand, is to build up a large self-contained concern on lines somewhat similar to the A.E.G., of Berlin. In this way it is hoped to reduce both manufacturing and selling costs, and so to place the firm in the best possible position to compete in home and foreign markets. The whole programme of the firm, which is not yet completed, includes the acquisition of the business of Messrs. Chamberlain and Hookham, a jute factory, and other works, as well as the construction of additional factories for the manufacture of telephones, switchgear, &c. The whole scheme involves an expenditure approaching 2,000,000*l.*, and is evidence of the faith of the directors in the future prospects of British industries. At the moment the work at Erith, as might be expected, is greatly hampered by the moulders' strike, the foundry being quite closed down and other departments working only three days a week. The shops, however, contain a number of interesting productions, some of which we hope to describe in detail on another occasion.

## THE TERNARY ALLOYS OF TIN-ANTIMONY-ARSENIC *

By Dr. J. E. Stead, D.Sc., D.Met., F.R.S., Member (Middlesbrough), with Notes by Mr. L. J. Spencer, M.A., F.G.S. (Natural History Museum).

In a paper read before the Society of Chemical Industry in February, 1897,† the author gave a preliminary description of some of the alloys of tin-antimony, tin-arsenic, and tin-phosphorus. To understand the ternary alloys of tin-antimony-arsenic, it is necessary to refer to that paper, as the results given therein led to the discovery of a most remarkable alloy to be described presently.

*Tin-Antimony.*—Tin and antimony alloy together in all proportions. Until the antimony exceeds 7½ per cent. the alloys consist of crystallites of tin containing SnSb in solid solution. When the antimony slightly exceeds 7½ per cent. hard white cuboidal crystals appear near the upper surface of the slowly-cooled alloys, which increase in number with the percentage of antimony. They are specifically lighter than the matrix containing 92·5 per cent. tin and float upward, becoming loosely packed in the upper surface layers of the alloy. The specific gravity of antimony is 6·713, that of tin is 7·29, and of the crystals 6·96. When the antimony reaches about 25 per cent., and the alloy is cooled in 10 minutes, the cuboidal hard crystals, owing to looseness in packing, are distributed evenly from top to bottom of the alloy, the intercrystalline spaces being filled with the solid motor liquor. If the cooling is very much slower, and the metal is shaken during solidification, the crystals come much closer together. This modern substance—called a eutectic—does not, like most eutectics, separate into its constituents at the point of solidification, but the antimony and tin remain a solid solution. All the alloys of tin and antimony containing less than 7½ per cent. antimony and more than 92½ per cent. tin, crystallise during solidification in the same aborescent forms as pure tin. Like tin, the cast alloys at the point of incipient fusion can be readily broken along the junctions of the crystallites. On etching with dilute nitric acid, the surfaces of the cast alloys, containing less than 7½ per cent. antimony as well as tin and lead, are all most readily attacked at the junctions of the crystallites, and on repolishing the strongly etched surfaces there remain deep channels between the crystallites, as shown in Fig. 1. The same metals and alloys in the cast state are specifically lighter than after they have been subjected to strong pressure, and, incidentally, the selective attack by nitric acid at the junctions of the crystallites of the compressed metals diminishes. The appended table gives examples of this property shown in round prisms of the cast metals, ½ in. in diameter, before and after compression.

| — | Specific Gravities. | | |
|---|---|---|---|
| | As Cast. | After Compression. | Difference |
| Commercial lead .. .. | 11·308 | 11·381 | +0·073 |
| Block tin .. .. .. .. | 7·219 | 7·333 | +0·114 |
| Eutectic lead and antimony .. .. .. | 10·125 | 10·365 | +0·240 |
| Eutectic tin and antimony | 7·304 | 7·318 | +0·014 |

It may be tentatively assumed, therefore, that during solidification and cooling the very last portions to "set" at the junctions contain somewhat porous metal caused by the branches of the crystallites contracting towards their central axes.* The cooling curve plotted by the thermal method shows only one marked arrest corresponding to the solidifying point of the eutectic.

*Solidifying Points of Tin, Antimony, and their Eutectic.*

| | | Deg. C. |
|---|---|---|
| Tin ... ... ... ... ... | | 232 |
| Antimony ... ... ... ... | | 630 |
| Tin, 75 per cent. | Primary arrest | 338 |
| Antimony, 25 per cent. | Final arrest ... | 245 |
| Tin-antimony eutectic | Stead ... | 245 |
| | Goerens ... | 243 |

It would appear from these observations that the eutectic of tin-antimony freezes at 16·85 deg. below the mean freezing temperature of its constituents.

The crystals which fall out of solution in the alloys containing between 8 per cent. and 25 per cent. antimony, being insoluble in 10 per cent. solution of nitric acid in water, whilst the matrix is attacked, were readily obtained in the free state. Under the microscope many of the crystals appear to be perfect cubes, and one face in Fig. 2, had angles of 90 deg. at each corner. The faces, however, are dull, and on that account the crystals are not suitable for measurement goniometrically. The chemical composition of the separated crystals from alloys containing 10 per cent. and 20 per cent. antimony correspond closely to SnSb (49·7 per cent. Sn, 50·3 per cent. Sb) or Sn 49·46 per cent., Sb 50·54 per cent. When the antimony exceeds 25 per cent. in the alloys the character of the primary crystals gradually changes, and in section appear as prismatic bodies, but are badly formed plates irregularly packed, with the intervening spaces filled with the matrix containing about 7½ per cent. antimony. This structure persists until the antimony reaches about 55 per cent., when the whole mass consists of connected plates free from intervening eutectic. With the formation of the plates the white crystals no longer appear to be homogeneous, for, on strongly etching, the attack is more severe at the boundaries and less so at the centre of the crystals—showing that the antimony-tin substance which first falls out of solution is no longer SbSn, but contains a greater proportion of antimony than is represented by that formula. On melting a considerable quantity of the cuboidal crystals under potassium cyanide and cooling slowly, the microstructure of the cold alloy was identical with that of an alloy containing equal parts of the two metals, and the crystals no longer appeared as cubes, but as short plates containing intercrystalline fillings of the eutectic. It is evident, therefore, that on melting SbSn it is decomposed, and on solidifying, crystals containing more than the SbSn proportion first form on cooling, and on their surfaces SbSn deposits, whilst a mother substance containing 7½ per cent. antimony finally freezes. As the antimony becomes increasingly greater the first crystals that form appear to become correspondingly richer in antimony.

*Tin and Arsenic.*—Tin in a molten condition at about 800 deg. C. will alloy with as much as 43 per cent. arsenic, but on long heating such an alloy at higher temperatures much of the arsenic is volatilised. Having such an alloy, it was easy to make a complete series of Sn + As alloys by simply melting various weights of tin and the rich alloy together under potassium cyanide. In the cold alloys containing between 0·05 per cent. and 10 per cent. arsenic, hard plates appear in the cut, polished and etched sections as straight white lines, which are really section of flat plates. (See Fig. 3.) Practically the whole of the arsenic separates out in these crystals, and the matrix then contains only traces of arsenic. On very slowly cooling an alloy containing 99·5 per cent. tin and 0·5 per cent. arsenic, the crystals float upwards and are concentrated in the upper layers, and below this is the mother substance practically free from crystals of arsenide of tin. Micro-examination, however, reveals the fact that between the branches of

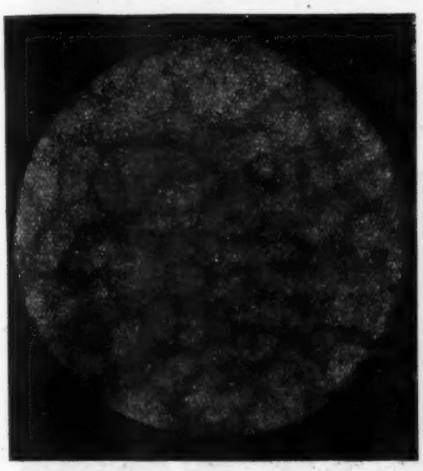


Fig. 1. Tin, 92.5 per Cent.; Antimony, 7.5 per Cent.; Eutectic. × 50.

Fig. 2. Tin, 80 per Cent.; Antimony, 20 per Cent.; Crystals of Sn Sb. × 50.

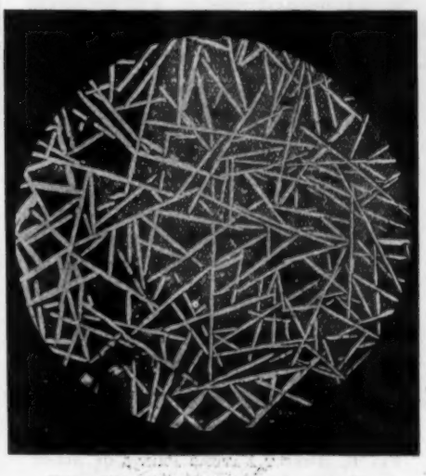


Fig. 3. Tin, 95 per Cent; Arsenic, 5 per Cent.; × 2. Crystal of $Sn_3As_2$.

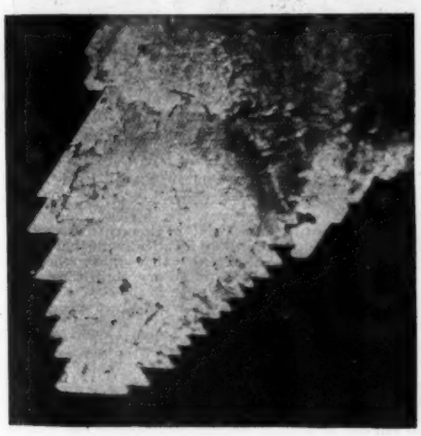


Fig. 4. Separated Crystals of $Sn_3As_2$. × 50.

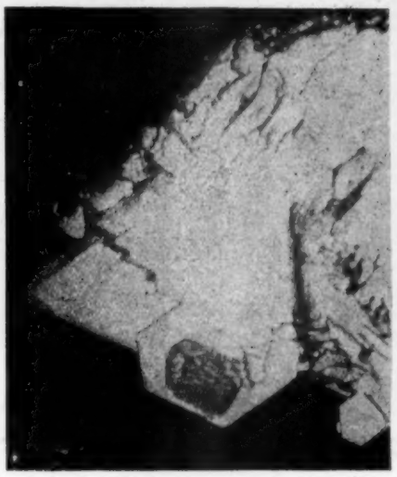


Fig. 5 Separated Crystals of $Sn_3As_2$. × 50.

* Paper read before the Institute of Metals, September 24, 1919.

† Journal of the Society of Chemical Industry, vol. xvi, page 200.

* The crystallites in certain alloys of iron and nickel do actually partially separate on solidification.

the crystallites of the matrix minute plates of the arsenide are located. On treating a portion of this solid mother substance with dilute nitro-hydrochloric acid these minute crystals were left undissolved. The matrix contained a total of 0·15 per cent. arsenic, and the residual arsenide 0·12 per cent. arsenic, leaving 0·03 per cent. not accounted for. The solidifying point of the separated mother substance was 232 deg. C., and the final arrest during solidification of the alloys containing respectively 5 per cent., 10 per cent. and 20 per cent. arsenic was also 232 deg. C., which is identical with that of pure tin. It may be accepted, therefore, that the mother substance is not a eutectic of tin and arsenic, but consists of pure tin. Phosphide of tin is analogous to the arsenide, crystallising out of tin in the same idiomorphic form, leaving a matrix of pure tin. On examining the crystals under the microscope, one finds they have true idiomorphic form, Figs. 4 and 5. Mr. L. J. Spencer, of the Natural History Museum, London, has kindly examined them for the author, and has furnished the following interesting data :—

"*Crystals of Tin Arsenide* ($Sn_3As_2$).—The crystals were separated by Dr. J. E. Stead, F.R.S., from an alloy containing 95 per cent. tin and 5 per cent. arsenic. They

Fig. 6. Direct Nature Prints of Alloy Containing Sn 70, Sb 25, As 5 per Cent.

Fig. 11. Alloy Chilled in Water after First Arrest. × 50.

have the form of small thin scales, about 2 mm. across, with much the appearance of flakes of graphite. The colour is steel grey with a bright metallic lustre. They are quite soft, readily marking paper, and are flexible, but not elastic. The outline of the flakes is usually irregular, but at times it is clearly triangular or hexagonal. Under the microscope these give angles of 120 deg. and 60 deg., and lines on the surface of the scales are inclined to one another at the same angles. The edges of the scales are often deeply and regularly serrated, having quite the appearance of a saw with obliquely cut triangular teeth. This is due to an alternate repetition of the faces of the rhombohedron which form the edges of the crystals. The crystals are rhombohedral (trigonal), and the only faces present are the large basal plane $c(111)$, forming the surface of the scales, and the rhombohedron $r(100)$ at the edges, the latter being represented by narrow planes or by a series of small triangular facets. There is a perfect cleavage, $c(111)$, parallel to the surface of the scales. The images seen in the goniometer are rather scattered, and only approximate measurements can be obtained, viz. :—

$cr\,(111) : (100) = 55° 22'$ (limits, $55° 2' - 55° 48'$),

corresponding with the axial ratio :

$$a : c = 1 : 1·2538.$$

"This angle approximates closely to the cubic angle $(111) : (100) = 54$ deg. 44 minutes; and it might be suggested that the crystals are really cubic, being flattened parallel to a pair of octahedron faces and with cube faces at the edges. If this were the case, we should expect to find some traces of the six suppressed octahedron faces at the edges in the zones 111, 100. Again, the cleavage would be octahedral instead of only basal, but no indication of a cleavage across the plates was detected.

"The crystals agree closely in their characters, and are no doubt identical with those described by W. P. Headden* from Cornish tin works. His analysis gave the formula $Sn_6As$, but he mentions difficulty in separating the crystals from globules of tin.

"He believed the six-sided plates to be rhombohedral. Headden's crystals were subsequently measured by S. Stevanovic,† who determined them to be trigonal with $cr = 54° 51'$, corresponding with $a : c = 1 : 1·2299$.

"If the formulæ $Sn_3As_2$ and $Sn_6As$ correctly represent the composition of the crystals, there is perhaps some relation between their angles and those of arsenic (which also is rhombohedral with a perfect basal cleavage), since

Fig. 7. Fragment of Alloy showing Direction of Curved Fractures.

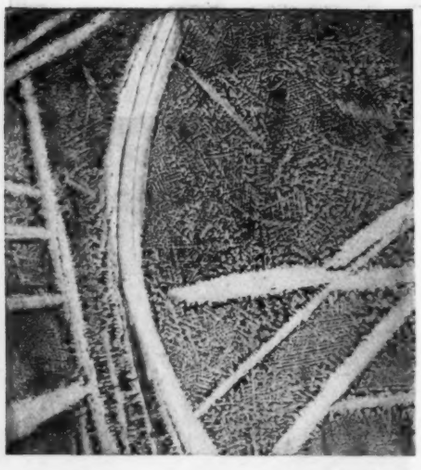


Fig. 12. Same Alloy as Fig. 11. Chilled Less Rapidly.

these of $Sn_3As_2$ lie between the corresponding values for SnAs and As.

| | SnAs. | $Sn_3As_2$. | As. |
|---|---|---|---|
| $cr\,(111) : (100)$ | 54° 51′ | 55° 22′ | 58° 17′ |
| $a : c$ ... ... | 1·2299 | 1·2538 | 1·4013 |

His error in stating the chemical formula is corrected by P. Groth,"‡

Analysis of several crops of crystals in the author's laboratory yielded results approximating to $Sn_3As_2$.

*Tin-Antimony-Arsenic.*—Having found that the alloys of antimony and tin yield what appeared to be cubic crystals, and tin and arsenic rhombohedral flat plates, a trial was made to find how the metals would arrange themselves when the three elements were alloyed by fusion and the liquid allowed to cool down slowly. The results obtained were astonishing, for the crystals found in the matrix were in the form of incompleted spherical shells, the radii of which were minute or great, in proportion to the time allowed for development. When solidification was effected in one second the radius was less than ¼ mm., but when protracted for 1 hour, it was 5 mm. or more. The most perfect structural arrangement of the crystals was obtained in an alloy containing

* W. P. Headden, Proceedings of the Colorado Scientific Society (1901), vol. vi (for 1897–1900), page 80 ; *American Journal of Science*, 1898, ser. 4, vol. v, page 95.

† S. Stevanovic, *Zeitschrift für Krystallographie Mineral*, 1905, vol. xl., page 326.

‡ *Chemische Krystallographie*, 1906, Part i, page 66.

70 per cent. and 85 per cent. tin, 25 per cent. and 18 per cent. antimony, and 4 per cent. to 5 per cent. arsenic. Whether cooled slowly or quickly, the polished surfaces of the alloys, after dissolving away the matrix, were admirably suitable for printing blocks, because the hard crystals stand out in bold relief. (See Nature prints, Figs. 6 and 7.) The alloys are exceedingly brittle, and fracture always travels along midway between the shell walls. Figs. 8 and 9 represent a fractured surface, slightly magnified, and clearly show the spheroidal character of the cleavages.

*Critical Points observed on Cooling.*—The alloy containing tin 70 per cent., antimony 25 per cent., arsenic 5 per cent., gave the following arrests, namely :—

1. The point of solidification of first crystals, 440 deg. C.
2. A retardation in cooling between 320 deg. and 325 deg. C.
3. Solidification of the eutectic, 244·9 deg. C.

The initial and final points of solidification of several other tin-antimony-arsenic alloys were as follows :—

| | | | |
|---|---|---|---|
| Tin ... ... | 73·4 | 71·4 | 68·1 |
| Antimony ... | 24·5 | 23·8 | 22·7 |
| Arsenic ... | 2·1 | 4·8 | 9·2 |
| | Deg. C. | Deg. C. | Deg. C. |
| Primary arrest | 363·0 | 439·0 | 479·0 |
| Final arrest ... | 244·8 | 244·8 | 244·8 |

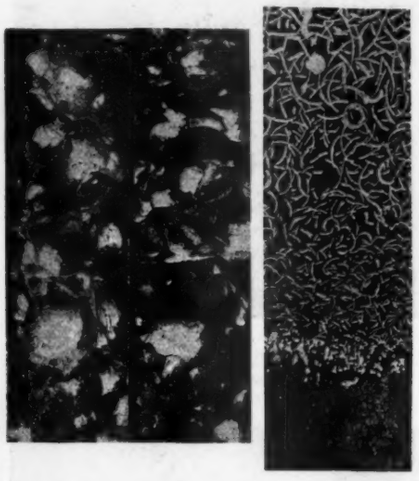


Fig. 8. Fig. 9 Fig. 10.

Fig. 8. Cleavage Fractures in Spherical Crystals, Vertically ; Fig. 9. Obliquely Illuminated. × 1½.

Fig. 10. Section of Alloy, Sn 85, Sb 14.35, As 1.65 per Cent. × 4.

The constant freezing-point of the eutectics of all these alloys, being practically identical with that of the tin-antimony alloys, suggests that they all have the same composition and that there is no arsenic in them. To determine definitely whether such is the case, a portion of the pure eutectic from a ternary alloy was chemically examined and was found to contain only a trace of arsenic (under 0·01 per cent.). As will be shown presently, the primary crystals of all the ternary alloys contain the maximum amount of arsenic, and that, as the crystalline substance which subsequently falls out of solution and deposits on the primaries contains less and less arsenic, it is probable that the crystals that last of all fall out of solution contain considerably less of that element. It is suggested, in view of the fact that the first freezing-point of the alloy containing 75 per cent. tin and 25 per cent. antimony is not far removed from the range of retardation in the ternary alloy, 320 deg. to 327 deg. C., that it synchronises with the change of crystalline form of the crystals.

*Chemical and Synthetical Investigation.*—A large number of definite mixtures of tin, antimony and arsenic were prepared, and these, after microscopical examination, were submitted to chemical analysis in order to find out, if possible, the composition of the crystals. The first point was to determine how much arsenic in the crystals was necessary to yield spherical forms. Four mixtures were made, and these, together with the separated crystals, had the following composition :—

| — | No. 1. | | No. 2. | | No. 3. | | No. 4. | |
|---|---|---|---|---|---|---|---|---|
| | Alloy. | Crystals. | Alloy. | Crystals. | Alloy. | Crystals. | Alloy. | Crystals. |
| | p.c. | p.c. | p.c. | p.c. | p.c. | p.c. | p.c. | p.c. |
| Tin .. .. .. | 74·5 | 52·7 | 74 | 55·7 | 73 | 56·5 | 72·5 | 50·7 |
| Antimony .. .. | 25·0 | 45·0 | 25 | 41·0 | 25 | 39·5 | 25·0 | 43·0 |
| Arsenic.. .. .. | 0·5 | 2·3 | 1 | 3·3 | 2 | 4·0 | 2·5 | 6·3 |
| Character of crystals | Cuboidal | | Cuboidal | | Cuboidal | | Curved | |

The No. 4 alloy contained mixtures of cuboidal and slightly curved crystals.

Other mixtures containing the same proportion of antimony, but more than 2·5 per cent. arsenic, yielded at first segments of spheres, and as the arsenic was increased more and more completed spherical shells. It is difficult to determine by calculation the true chemical constitution of the crystals high in arsenic, for they obviously consist of more than one chemical compound. Having found that the cuboidal crystals begin to pass into spherical forms when the arsenic exceeds about 6 per cent., the second point of interest was to determine the amount of antimony in the alloys necessary to change the flat rhomboidal plates into spherical forms. With this object a series of alloys was made containing arsenic 5 per cent. and antimony in varying proportions, viz. :—

| — | 1. | 2. | 3. | 4. |
|---|---|---|---|---|
| Tin .. .. | 95·0 | 91·0 | 86·5 | 85·0 |
| Antimony .. | nil | 4·0 | 8·5 | 10·0 |
| Arsenic .. .. | 5·0 | 5·0 | 5·0 | 5·0 |

No. 1, being free from antimony, yielded only flat plates; No. 2 had a structure identical with No. 1; Nos. 3 and 4 contained sections of spherical crystals of considerable radius. Further mixtures were made, in which all three elements were variable, as tabulated on the next page.

It will be noted that whilst it required about 2·5 per cent. arsenic in presence of 25 per cent. antimony to produce slightly curved crystals, when the antimony is considerably reduced even 0·5 per cent. arsenic in presence of 3·75 per cent. antimony yields curved segments in the upper layers. The most interesting alloy is that shown in Fig. 10, for in this alloy one finds spherical crystals in the top layers, smaller segments below these, and under the latter cuboidal crystals, whilst the lowest portion consists of the eutectic free from any white crystals. It is evident that the compound richest in arsenic first fell out of solution and floated upward through the liquid metal to near the surface; following these, crystals forming small segments of spherical shells—containing less arsenic—then fell out of solution and lodged below the first crystals; after these, when the arsenic remaining was very low, cuboidal crystals fell out and lodged below the others, and finally, the eutectic solidified. This is clearly shown in Fig. 10.

In the instance just quoted the arsenic and antimony together were about 16 per cent. and the tin 84 per cent., and in such dilute solution the four separate stages of crystal growth can be seen. When, however, the proportion of antimony is between 20 per cent. and 25 per cent. and the arsenic about 5 per cent., the primary crystals that fall out are distributed evenly through the whole mass of the alloy, and there is no stratification. That there is the same gradual change from stage to stage in these alloys was demonstrated by subjecting the cooling alloys to pressure and filtration at definite temperatures so as to leave the crystals behind and obtain liquids in a separate state. By this means one obtained liquates after their solidification containing segments of spherical shell, spherical shells passing into cuboidal forms, perfect cubical crystals, and finally the pure eutectic. That the primary crystals which form in the same alloys are spherical shell crystals was proved by suddenly chilling them shortly after the first thermal arrest. Fig. 11 represents the structure after quenching in water. Sections of the crystal shells are clearly shown perfectly smooth on the concave side but slightly broken on the other or convex side—possibly due to the violent disturbance produced on quenching. The experiment was repeated, but instead of plunging the whole alloy into water the metal was cooled by placing the bottom of the crucible into cold water. Fig. 12 represents the structure, magnified 50 diameters, from which it will be seen that in the metal cooled in this way the curve is unbroken on each side and free from fragments the curve is unbroken on each side and free from fragments. After very slow cooling the outside parts of the apparent curves were found to consist of cubical crystals, and in Figs. 13 and 14, magnified 50 diameters, not only can indications of this be seen, but a few cubic forms are seen to be quite independently embedded in the eutectic.

On etching the 70 : 25 : 5 alloy with dilute nitric acid for 10 minutes, the whole of the crystals remained perfectly white, but on leaving the polished section in the solution for 12 hours the primary crystalline substance alone remained white, whilst the exterior portions became dark, the junction between the two being clearly marked. This is shown in Figs. 15 and 16, representing a magnification of only four diameters. On long polishing on cloth covered with fine alumina powder the central parts of the shells remained in slight relief, showing that the primary crystals are slightly harder than the exterior crystalline substance. No means could be found of separating the primaries and obtaining their composition, but there can be little doubt, judging from other experiments, that they contained a maximum amount of arsenic and antimony.

*Influence of other Elements.*—On mixing and melting together the 70 per cent. tin, 25 per cent. antimony, and 5 per cent. arsenic alloy with lead in varying proportions from 10 per cent. to 20 per cent., the spherical character of the crystals persisted, the only apparent difference being that the proportion of the matrix was increased. On mixing with 10 per cent. copper, a similar result was obtained, but the eutectic decreased, and through the whole alloy thread-like branched crystals of a new constituent appeared—probably the definite compound $Cu_8n$. Whether a portion of the copper crystallised out in the spherical crystals was not determined. On diluting the last alloy with 20 per cent. lead, the only change effected was that the proportion of the eutectic was increased. When only 0·5 per cent. copper was added to the alloy apparently no structural change was produced and no thread-like constituent could be detected, suggesting that the smaller quantity of copper

Fig. 13. Outside and Eutectic of Alloy 70/25/5. × 50.

Fig. 14. Same Alloy as Fig. 13. × 50.

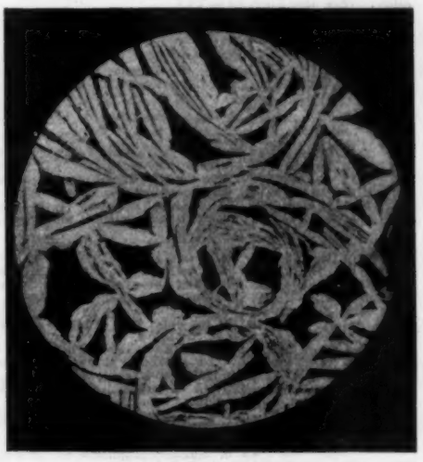


Fig. 15. Sn 70, Sb. 25, As 5 per Cent. Alloy. Etched for 10 Minutes. × 4.

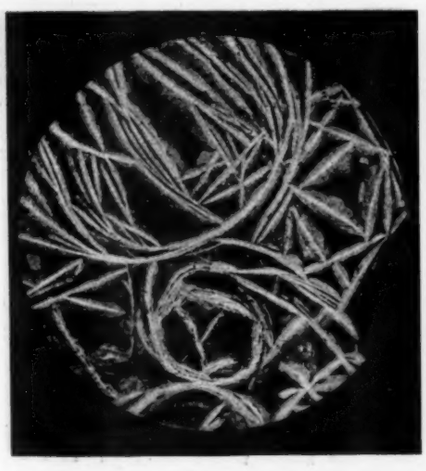


Fig. 16. Sn 70, Sb 20, As 5 per Cent. Alloy. Etched for 12 Hours. × 4.

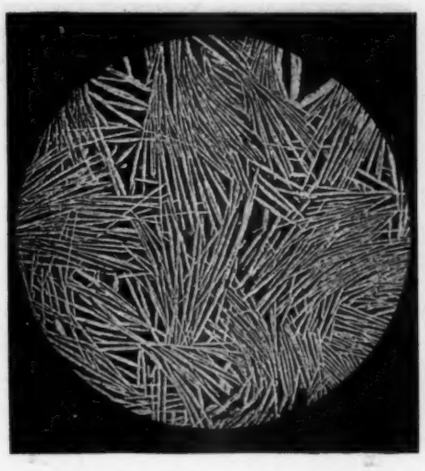


Fig. 17. Crystallised out of Lead-Tin Eutectic. × 2.

Fig. 18. Sn 85, Sb 10, As 5 per Cent. Alloy. × 2.

crystallised out in the spherical crystals. The question naturally presented itself: Would spherical crystals form if, instead of having a eutectic of tin and antimony as the mother liquor, the latter were replaced by the eutectic of tin and lead on the one hand and lead and antimony on the other? To answer this question, the respective eutectics were prepared, and with each an equal weight of an alloy having the composition of the crystals in the 70 per cent. tin, 25 per cent. antimony, 5 per cent. arsenic alloy was added, and, after melting and slowly cooling, were polished and etched. The crystals in the lead-tin eutectic were all curved and of large radius. Fig. 17, magnified two diameters, represents this and somewhat resembles the alloy containing 85 per cent. tin, 10 per cent. antimony, and 5 per cent. arsenic, illustrated in Fig. 18. The crystals in the lead-antimony eutectic resemble those in the original SnSbAs alloy. (See also Figs. 19 to 21.)

| No. | Tin. | Antimony. | Arsenic. | Remarks. |
|---|---|---|---|---|
| | p.c. | p.c. | p.c. | |
| 1 | 74·0 | 21·6 | 4·4 | These all had the same character and spherical crystals, the quantity of the crystals diminishing with the antimony and arsenic. |
| 2 | 77·0 | 18·8 | 4·0 | |
| 3 | 76·5 | 20·0 | 3·5 | |
| 4 | 77·3 | 19·4 | 3·5 | |
| 5 | 78·63 | 18·07 | 3·3 | This was similar to No. 4, but the crystals were in short segments of spheres. |
| 6 | 77·0 | 20·0 | 3·0 | This contained spherical segments. |
| 7 | 79·0 | 18·0 | 3·0 | Similar to No. 6. |
| 8 | 81·0 | 16·0 | 3·0 | Similar to No. 6, but crystals diminishing and eutectic increasing as the antimony and arsenic decreased. |
| 9 | 81·3 | 16·0 | 2·5 | |
| 10 | 87·0 | 11·0 | 2·8 | |
| 11 | 84·8 | 13·2 | 2·0 | Contained detached spherical segments at the upper part of ingots and the eutectic below. |
| 12 | 83·2 | 14·6 | 2·2 | Segments of spherical shells. |
| 13 | 85·0 | 14·35 | 1·65 | Curved segments at top, cubes in middle, eutectic below. |
| 14 | 86·25 | 12·75 | 1·0 | Crystals all cuboidal at top, eutectic below. |
| 15 | 88·7 | 10·5 | 1·0 | Small spherical segments at top, eutectic below. |
| 16 | 88·0 | 11·0 | 0·8 | Cuboidal crystals at top, with traces of spherical segments at corners, eutectic below. |
| 17 | 89·3 | 9·8 | 0·9 | All cubes in top layers, eutectic below. |
| 18 | 99·3 | 9·2 | 0·5 | All cubes in top layers, eutectic below. |
| 19 | 90·5 | 9·0 | 0·5 | All cubes in top layers, eutectic below. |
| 20 | 92·55 | 7·0 | 0·95 | Curved segments at top, eutectic below |
| 21 | 95·78 | 3·75 | 0·47 | Curved segments at top, eutectic below. |

On reviewing all the experiments the question arose as to whether spherical crystals would develop in an alloy free from tin. To settle this point an alloy was made containing 70 per cent. lead, 25 per cent. antimony, and 5 per cent. arsenic. The alloy contained spherical crystals, the shells of which were very thin, and on the surfaces of these there were crystals of quite an indeterminate character. (Fig. 22.) On melting this alloy with an equal weight of lead the crystals in the solid alloy were cuboidal.

Although the results of this research are interesting and instructive, they suggest and indicate that much more work must be done before finality can be reached.

### Notes upon Curved Crystals in Minerals.

Mr. L. J. Spencer has kindly furnished most important data with regard to curvature of crystals in minerals for publication in this paper. Mr. Spencer states that this branch of the subject has been somewhat neglected, and much remains to be learnt regarding it. As his complete notes have been communicated to the Mineralogical Society, those interested are referred to the proceedings of that society. It is sufficient here to review briefly the data he has collected.

"*Curved Crystallites* occur as hair-like feathery forms in glassy igneous rocks, and in a more advanced stage of development as feathery microlites of felspar, augite, &c. They are also present in silicate fusions made in artificially produced rocks. The frost crystal patterns on window panes are notable examples of curvature in crystals. The conditions under which they are formed are conducive to twin-growths, and it is probable that the curvature is the result of twinning in the endeavour of the crystals to find constantly fresh directions of growth when hindered by viscosity or surface tension from free idiomorphic development.

"*Capillary Habit* is of frequent occurrence amongst minerals of many kinds, but these fine hair-like crystals may not only be bent and twisted, but may form matted, woolly, felted, or even compact aggregates. Types of these are chalcotrichite, halotrichite, plumosite, pilolite, erionite, crocidolite. Other fibrous minerals of the same character are hair-salt or alunogen, millerite, asbestos, &c.

"Chalcotrichite affords a peculiar instance of irregular development. Crystals of cuprite are, as a rule, well and equally developed, but in the chalcotrichite variety they become enormously elongated in the direction of an edge of the cube. The same also happens in the case of kalinite or potash-alum.

"*Aggregations of Crystals* give rise to a great variety of indeterminate forms, usually with curved surfaces and described as globular, botryoidal, &c.

"The curvature due to deviation from parallelism between adjacent crystals may be only small, but if this slight difference is repeated in the same sense through a long series of small individuals a curved surface will result.

"*Interfacial Oscillation.*—A step-like repetition of two adjacent faces on a simple crystal may give rise to the rounding of an edge or to wider surfaces marked by striations parallel to that edge. Here the curvature is cylindrical, with the edge in question as axis. A common example of this is seen in crystals of iron pyrites with the cube and the pentagonal-dodecahedron $e(210)$, in combination. Calcite crystals are very often much striated and rounded between the faces $r(100)$ and $e(110)$; and when these are the only forms present the crystals may be lenticular.

"*Vicinal Faces* are perhaps the most commonsense of the curvature of the surfaces of simple crystals. A progressive succession of such faces with small angles between small adjacent faces would give rise to a curved surface. Good examples are afforded by the lenticular crystals of gypsum and phacolite (so named from φακός, a lentil), and by crystals of diamond, of which many good illustrations are given by A. von Fersmann and V. Goldschmidt.*

"*Bent Crystals.*—Subsequent to their growth, mineral crystals may be broken or bent by earth pressures. Prismatic crystals of tourmaline, beryl, quartz, actinolite, gypsum, chlorite, &c., are sometimes bent in this way. Fibrous minerals of various kinds occurring as a filling in rock crevices, and with the fibres arranged perpendicularly to the walls, frequently show a curved or zigzag bending of their fibres, due to a differential movement of the rock walls.

"The bending or plastic deformation of crystals is, in fact, a common phenomenon, and is due to secondary twinning or simple translation, induced by pressure along certain planes, known as glide planes.

"*Twisted Crystals.*—Perhaps the most striking instance of curvature in crystals is that presented by the twisted crystals of smoky quartz from the Swiss Alps. These crystals have a spiral twist about one of the horizontal diagonal axes, the screw being right-handed in right-handed crystals and left-handed in left-handed crystals.

"Twisted crystals of another kind with a double curvature are well known in the saddle-shaped crystals of dolomite.† A similar effect is also seen in the crystals of the plagionite-semseyite group of minerals which form a morphotropic series ranging in composition from $5PbS.4Sb_2S_3$ to $9PbS.4Sb_2S_3$. Here the habit of the crystals is the same for different members of the group, but the angles vary slightly with the chemical composition. In a compound crystal built up of smaller crystals of different composition there would be a lack of parallelism, and distorted and twisted surfaces would result. I have also suggested* that the same explanation may hold good in the case of the twisted crystals of dolomite, or rather 'brown spar,' since pure dolomite, $MgCa(CO_3)_2$, yields very sharply developed crystals.

"*Cylindrical and Spherical Crystals* (?).—The curious case of kylindrite (from κυλινδρος, a roll) is considered apart, as it does not appear at first sight to fall into any of the groups considered above. This mineral is a sulphur salt of tin, lead, antimony and iron, with the formula† $Pb_3FeSn_4Sb_2S_{14} = 3PbSnS_2 + SnFeSb_2S_4$. It has the appearance of consisting of tightly-wound rolls of foil with a smooth surface and brilliant metallic lustre. The ore consists of large numbers of these rolls with a more or less radial grouping. It has been found only at Poopó, near Oruro, in Bolivia, but there in some quantity. The rolls have a diameter of a few millimetres up to 1 cm., and reach a length of 3 cm. to 4 cm. They flake off in concentric cylindrical shells with all the appearance of a perfect cleavage very similar to that of the allied minerals franckeite and teallite. These cylindrically-curved cleavage flakes are perfectly bright and smooth and show no visible signs of being built up of smaller elements.

"Spherical aggregates of crystals possessing a perfect cleavage are, however, met with, but here a radial grouping is much more common than a concentric arrangement. Examples of radiating spherical aggregates of lamellar crystals with platy cleavage are pyrophyllite, zeophyllite, gyrolite, faröelite, tyrolite, &c. The 'pudding granite' of Vermont contains balls of

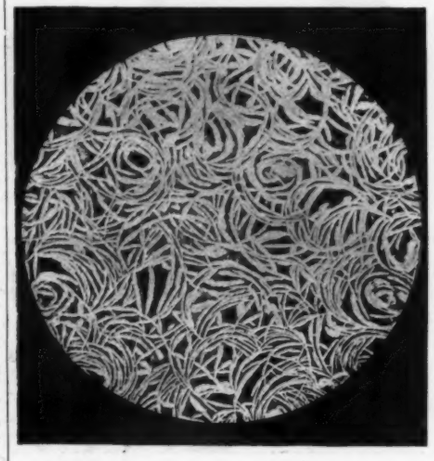


Fig. 19. Sn 75, Sb 20, As 5 per Cent. Alloy. × 2.

Fig. 20. Sn 77, Sb 18, As 5 per Cent Alloy. × 2.

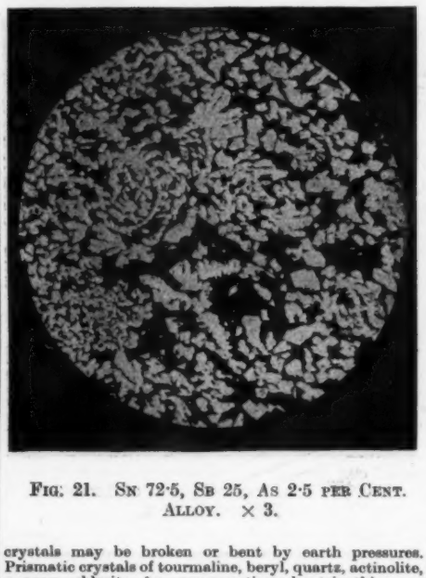


Fig. 21. Sn 72·5, Sb 25, As 2·5 per Cent. Alloy. × 3.

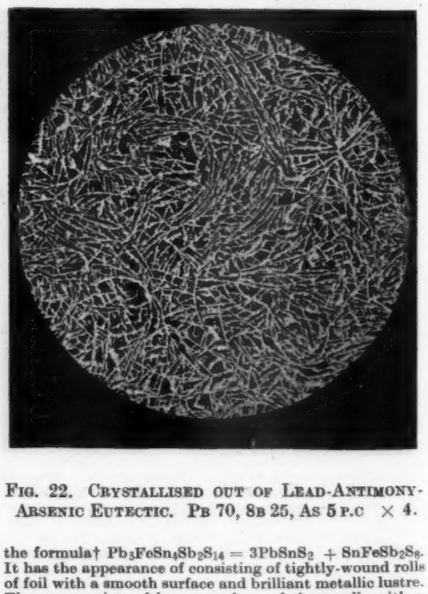


Fig. 22. Crystallised out of Lead-Antimony-Arsenic Eutectic. Pb 70, Sb 25, As 5 p.c. × 4.

* *Der Diamant*, 1911.

† Miers, *Mineralogy*, 1902, page 402, Fig. 545.

* *Mineralogical Magazine*, 1899, vol. xii, page 68.

† G. T. Prior, *Mineralogical Magazine*, 1904, vol. xiv, page 26.

Muscovite with a grouping of the scales roughly parallel to the surface.

"We are thus referred back again to forms of aggregation considered earlier; and it seems most probable that this is the explanation of the cylinders of kylindrite and the curious spherical shells of the tin-antimony-arsenic alloy described by Dr. Stead."

*Curved Crystals in Metals and Alloys.*—There are many examples of curvature of crystals and crystallites in metals. Ingots of antimony often have curved crystallites clearly marked on their surfaces, and, on fracturing the metal, along the curved crystal branches, the cleavages are found to be distinctly curved, but under the microscope the curvature is seen to be made up of a multitude of flat cleavages arranged at slight angles to one another. Crystals of iron and many other ductile metals may be bent by mechanical force, but it is almost certain that the crystals after bending are equivalent to aggregations of many crystals arranged at slight angles, as in the case of antimony just referred to. Some crystals obtained from the cavities of steel ingots are often curved. Graphite crystals in grey pig-iron very frequently are in the form of segments of spherical shells, but when the graphite crystallises before the metal becomes solid and then floats to the surface the crystals are in the form of flat plates. No satisfactory explanation has been advanced why graphite should take the spherical shell form in metal which is in a semi-fluid or plastic condition. In the cases of curvature in mineral crystals, referred to by Mr. Spencer, none approach in character or are in the form of spherical shell crystals such as develop in the ternary alloys of tin, antimony, and arsenic. Radial crystallisation round a nucleus is common in minerals, but the spherical form finally produced is not a single crystal but an aggregation of many crystals. Kylindrite consists of a series of cylindrical crystals which have formed round a central axis and are not independent cylinders.

The author has no knowledge of any cases in metals in which the idiomorphic forms of the crystals are segments of spherical shells and which have crystallised out of a eutectic, excepting in the alloys described in this paper.

The reason why such idiomorphic shell crystals develop in a eutectic, and the laws which govern their formation, must be left for the consideration of crystallographers, and for further research.

Professor Bragg, to whom has been sent some of the separated crystals, has kindly promised to study them.

The alloys described are of no commercial use, but it is possible they may be utilised in the production of ornamental vases, boxes, buttons, paper-weights, &c. They are primarily interesting from the point of view of pure science.

In conclusion, I must acknowledge the valuable assistance of Mr. L. J. Spencer; Mr. E. W. Jackson, my chief chemist, who is responsible for the analyses; Mr. A. Scholes and Mr. F. A. Stead for the thermal and other investigations; and Mr. T. H. Bellwood. Thanks are also due to Mr. R. F. Pearce, of Messrs. Williams, Harvey and Co., Liverpool, who kindly supplied the pure tin, free from antimony and arsenic, for some of the experiments.

## THE HUMAN ELEMENT IN ENGINEERING.*

The general impression conveyed to my mind by a perusal of past presidential addresses, is that the material side of engineering has been exploited rather more than the personal or human element, and I propose to take advantage of my position here this evening to help to redress the balance.

For many years to come the world will want all the engineers it can produce to repair the ravages of war, for rebuilding, for reconstruction and for the opening-up of new countries and new trade routes. We can afford to neglect for the present the competition of aliens; there is work for all. It is, or it should be, the proud boast of the engineer that his particular work, rightly applied, is the greatest civilising agency that exists.

Railways, ships, motor cars, aircraft, bridges, tunnels, roads, docks, improved telegraphs and telephones, mechanical appliances in agriculture and mining, irrigation, lighting and power schemes, the storage preservation and transport of foodstuffs, good dwellings, sanitation, water supply—what vast fields of endeavour and enterprise for the vigorous youth with a spark of imagination! With education and training such as is provided for engineers in these days the well-equipped young man has the world at his feet in whichever direction he elects to turn.

But he must remember that all successful men—including engineers—are specialists, and however complete his general training may be, he must decide that he will be master of one thing, and, if possible, a paramount authority on that subject.

I do feel very strongly that engineers, as a class, are too inarticulate. They prefer that their achievements should speak for them. There they make a big mistake. How often have we seen the credit for a clever piece of work filched from the man who was really responsible, just because he was too retiring or too altruistic to keep himself in evidence. I am not suggesting for one moment that a brother engineer would willingly or wittingly rob another of the work of his hand and brain. Engineers, as a rule, are quick to recognise a meritorious performance. But in all large and complicated enterprises there are always others—those whose work is administrative, or clerical, or merely ornamental. These persons are apt to get into the limelight and take all the "kudos"; not consciously, maybe, but simply and solely because they happen to be the only men in sight. Marine engineers suffer a considerable measure of eclipse of this sort. Their best efforts, often masterpieces of ingenuity and design, are entombed in a kind of steel coffin, and never again see the light of day. And they themselves are out of sight also, and therefore out of mind. It took a "Titanic" disaster to impress upon a heedless world, the quiet heroism and devotion to duty that can exist down below among men who calmly control the volcanic energies of 100,000 h.p.:

There, if the young engineer is a draughtsman worthy of the name, he is daily and hourly, if not exactly inventing, at any rate working out improvements. It is the normal procedure in every well-regulated drawing office. No sooner is a new design completed—I refer now particularly to a plan of engines or turbines, or a general arrangement of machinery—than it immediately becomes obsolete. There is no finality in good engineering practice. However perfect a design may appear to be, the complete draughtsman can always go one better when he clears his board and starts afresh.

Frequently he never sees the actual work in the shops or on the ship, and so long as everything fits together and works all right, nothing more is heard of it. This is not as it should be. A little consideration, a word of commendation, to the man whose careful, conscientious thought and skill in the early stages of an important job have made it a triumphant success, is not only his due, but would go a long way to remove that feeling of injustice and dull resentment that was so pronounced in recent correspondence in the engineering papers. The fact is that the drawing office is, and should be, recognised as the brain-centre of the whole organisation. Any carelessness, the slightest mistake or miscalculation, may cause endless trouble and expense.

The time-honoured custom whereby engineering draughtsmen must have worked in the shops and become accustomed to the feel and touch of the materials of construction and the handling of tools is an eminently wise provision; and no doubt accounts for the marvellously few "bloomers" that occur.

It is a commonplace that millions of pounds worth of material is ordered and manipulated through the drawing office. Every plate, forging, casting, or detail goes into place and must be equal to the task it has to perform. If an engine, it must work sweetly and effectively for ever and a day. Now, in the rush of ordering material in the early stages of a job to maintain delivery dates according to contract, there is abundant opportunity for errors to creep in. But I think it will be generally admitted that the percentage of stuff that goes wrong or that has to be scrapped is infinitesimal; and this is only rendered possible by the particular and peculiar training of the engineering draughtsman to which I have referred. He is mentally building the engine, or boiler, or girder—as he draws the parts; and that makes all the difference between a practicable working drawing and one that is not.

Several firms in recent years have adopted a surprisingly enlightened policy. A system has been inaugurated whereby any such improvement produced by an employee meets with an immediate monetary reward as soon as its value is established. A patent is taken out in the joint names of the firm and the inventor, the firm paying all expenses, and allotting to the inventor a generous proportion of any royalties that may accrue. This is a pleasant contrast to the days not so long ago, when an employee who presumed to invent anything and patent it at his own expense, was looked upon with disfavour, and under suspicion of disloyalty. If the invention was good it was cheerfully appropriated by any unscrupulous manufacturer, who knew full well that the inventor could not afford to enter proceedings against him.

Generally, everybody, the whole community, gains by a well-protected and intelligently-developed invention. Unfortunately, the original inventor is sometimes victimised; but it is often his own fault. It is really comic to watch the antics of some amateur inventors. They ask for an interview, and then they are scared to death for fear you should tap their idea before you have committed yourself or your firm to buy a "pig in a poke." Often they have not dared to consult a patent agent. Not they! What is to prevent him twisting the thing round until they cannot recognise it, and then showing them that it has been done before? And as for the Government—why should they let the Government peddle the work of their brains at 6*d.* a time? It is all very wrong-headed, of course. You can make no progress with a man who distrusts you, and doubtless in some hard cases in the past there has been justification for his attitude.

The joint patent system, however, is a powerful protection for the employee and of advantage to all parties concerned. From what I have seen the system works well and has immense possibilities in cheapening and facilitating workshop methods.

One of the saddest things in life is to see a man, well past his prime, having worked faithfully and conscientiously all his days, looking forward with fearful apprehension to the time when he shall receive the polite intimation, "Your services are no longer required." Their one wish is to die in harness, so as not to become a burden at home. Too often, alas, their dismissal is tantamount to a sentence of death, and they do not survive long to be a burden to anybody.

Why all this bitterness and tribulation? Just because they had not the foresight when young to weigh themselves up and say, "Well, it is evident that I am never going to be anything more than a servant. I must see to it, before it is too late, that the firm or corporation I work for, has an adequate pension scheme, and that my declining days shall not be clouded by the spectre of want."

A young man, over twenty years ago, in the plenitude of his powers, decided to make the change. He was talented and brilliant, he had promise of quick promotion; but was content to suffer a considerable diminution in salary for the prospect of a sure pension and provision for his dependants. Several of his colleagues, who thought he was mad, have since gone under. He himself is looking forward with pleasurable anticipation to an early retirement, when he will be free to pursue the hobbies that have always engrossed his leisure hours.

There is no valid reason why any old employee should view the future with misgiving; on the other hand, it is only fair that the veterans, who have done their turn in the world's work, and have borne the burden and heat of their day, should not block the advance of the younger men. Autumn leaves must fall to make way for the spring foliage. Surely it should not surpass the wit of man for a federation of employers and insurance companies to evolve a scheme whereby these veterans would be saved from the anxiety and humiliation of hanging on to the means of a livelihood when they are getting past work. It would appear to be a comparatively simple thing to extend the Workmen's Insurance Act to include the higher grades and staff men. Something of the kind is in operation in the Foremen's Mutual Benefit Society. The cost and risk could be assessed from existing actuarial tables. The beneficiaries would be willing to contribute a fair share. Certificates should carry over from one firm to another as necessitated by the fluctuation of work, and in this connection the Government could, if it would, exercise a wise control which would make it a truly national institution. The ultimate result would be that a pension commensurate with the position to which the man had attained on retirement would follow naturally and automatically as a matter of course without any suggestion of favour, or grace, or consideration of special merit; and no one, whatever his circumstances, or however well-to-do, need be ashamed to accept it. Happily, there are signs of awakening. It is a hopeful sign when one finds the chairman of great business combinations employing tens of thousands of hands—going out of his way to preach and practise the new doctrine.

Why engineers should excel in altruism is a puzzle. It is a by-product of their profession. The engineer seems to be continually working himself out of a job for the good of others. He constructs a machine that does the work of 10,000 men, and makes it so perfect and fool-proof that it can be manipulated by a child. There is nothing left for him on that machine; he may go away anywhere, so long as it is out of sight—and invent another and a better one if he can. There was a time when it was considered necessary to have two chief engineers on a vessel fitted with a double trunk engine, one to look after each cylinder. Nowadays one chief has the responsibility of any number of cylinders driving three or four shafts. What a grand thing it would be if the starting handles could be geared up to the bridge and the engineer eliminated altogether! Does he complain? Not a bit! He would be the first to create such a mechanism, and make his owners a present of the idea, if it were possible—which it may be some day.

The "ca' canny" slogan has not yet been adopted by the engineer. I do not mean the fitter, or the mere engine driver; but the real complete engineer whose instinct it is to create, to invent, to design and construct. He can no more help doing it than can a doctor who is ready at any hour of the day or night to answer the call of duty; or the artist, or the poet, who must express himself on canvas or in verse whether it pays or not. In fact, the engineer in charge of a great installation of machinery, is in very much the same position as the house surgeon in some big institution. His job is not so much to work 8 hours a day manufacturing things; but to be always at his post, watching, thinking, measuring, recording, taking pressures and temperatures, sampling fuels, ash, oil, water—and ready for any and every emergency. When a joint blows out in the dead of night he doesn't expect to be paid at overtime rates because it isn't his watch. It will be calamitous if ever engineers become infected with that peculiar brand of trades unionism which involves paralysis and inaction in emergencies. Let them bargain as they will for better terms, wages, salary, or remuneration; but remember that this will not alter the character of their work; the conditions are fixed by the immutable laws of Nature. Assuming that they play their cards well, they may perhaps in time become as well off as the police force—good pay, sickness benefits and superannuation before they are worn out. If that can be "engineered" during this period of reconstruction it will be a great point gained.

The material side of engineering is fairly well provided for. One has no feeling of trepidation that the goods will not be delivered, or that they will not stand the stress and wear of active service.

Is it too much to expect that the *personnel*, the hand and brain workers in engineering, shall receive equal consideration with the *materiel*, the instruments and products of their labours? This great question is receiving anxious thought in influential quarters, and some tangible result is confidently looked for. Let shareholders once realise that they will not suffer financial loss, but will actually be the gainers, and the welcome change cannot be long delayed. All of us who have regard for law and other and constitutional measures, hope that the change will come about as harmoniously, and peacefully, as it will surely and inevitably. If any propagandist movement is necessary it is hoped that engineers will follow the lead of the medical and legal professions rather than that of the trades unions. It would be much more dignified and stately, and probably more effective.

* Abstract of presidential address read before the Liverpool Engineering Society by Mr. J. Hamilton Gibson, November 5, 1919.

# "ENGINEERING" ILLUSTRATED PATENT RECORD.

## SELECTED ABSTRACTS OF RECENT PUBLISHED SPECIFICATIONS UNDER THE ACT OF 1907.

*The number of views given in the Specification Drawings is stated in each case; where none is mentioned the Specification is not illustrated.*

*Where inventions are communicated from abroad, the Name, &c., of the Communicators are given in italics.*

*Copies of Specifications may be obtained at the Patent Office, Sales Branch, 25, Southampton Buildings, Chancery-lane, W.C., at the uniform price of 6d.*

*The date of the advertisement of the acceptance of a Complete Specification is, in each case, given after the abstract, unless the Patent has been sealed, when the word "Sealed" is appended.*

*Any person may, at any time within two months from the date of the advertisement of the acceptance of a Complete Specification, give notice at the Patent Office of opposition to the grant of a Patent on any grounds mentioned in the Act.*

### AERONAUTICS.

**130,637. D. J. Mooney, London, and P. J. Waldram, Hendon, London. Aircraft Structural Members.** (5 *Figs.*) February 27, 1918.—The invention relates to metal spars, girders and similar members of aircraft, having flange members of channel form and tubular web members secured in the channels of the flange members. The invention consists in securing the tubular web members to the arms of the flange members by through riveting, bolting or wiring. Fig. 1 illustrates one form

*Fig. 1.*

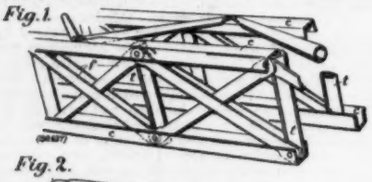
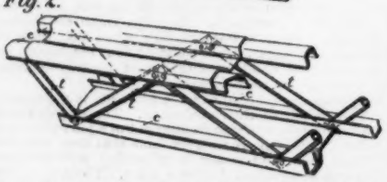
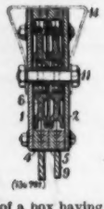


*Fig. 2.*



of built-up metal aeroplane spar of the character referred to consisting of channel flanges *c*, flat ties *f* and tubular posts *t*, through riveted to the arms of the flanges *c*. The ends of the tubular web members *t* may be plugged for riveting. Fig. 2 illustrates another form of girder in which the flat ties *f* and tubular posts in Fig. 1 are replaced by single tubular members *t* inclined to the longitudinal axis of the flanges to form a complete web structure and riveted to the arms of the flanges. (*Accepted August* 20, 1919.)

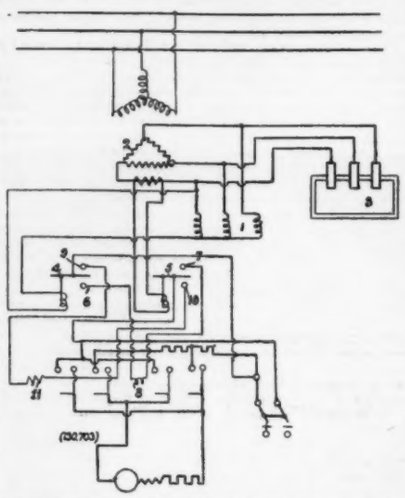
**130,791. Boulton and Paul, Limited, Norwich, and J. D. North, Burgh Apton, Norfolk. Aircraft Control Cables.** (5 *Figs.*) August 15, 1918.—The present invention refers to a casing or mounting for the pulleys over which the control cables pass in aircraft. According to this invention, the casing may be constructed to contain one or a plurality of pulleys 6 revoluble about a common axis, and in such a casing it is desirable that the construction should be simple, that the parts composing it should be readily disassembled or taken asunder so as to enable a cable 9 to be placed upon a pulley without the necessity of threading it through the guide holes formed in the casing, and at the same time the holes through which the cables pass on entering and leaving the casing should be formed in wear-resisting material, and further, such a casing should be capable of being easily fixed or attached to a stationary part of the aircraft and should be of economical construction. These requirements are met, according to this invention, by constructing



the casing in the form of a box having two side members 1, 2, separated by annular distance members 4, 5, forming the periphery of the box, within which box the pulley or pulleys 6 is, or are, located and supported by a spindle or bolt 11 passing through the side members and through the bearing, of the pulleys, the end of the bolt externally engaging or being supported by a bracket 14 of any suitable construction, which bracket can be fixed to a member of the aircraft. The cable for such a pulley passes into the box through the annular distance members over the pulley, and out of the box also through the annular members, forming the periphery, the passage holes for the cable being each formed in the contacting surfaces of a pair of such annular members, one portion of the hole being formed in one such annular member, and the other portion in the facing annular member, there being two such annular distancing members for each pulley, the composite structure described as composing the box being held together by, for instance, screws or bolts passing through the side members and through the annular distancing members. (*Accepted August* 20, 1919.)

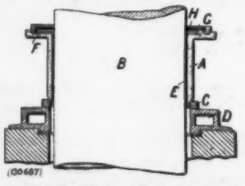
### ELECTRICAL APPARATUS.

**130,703. The British Thomson-Houston Company, Limited, London, and J. J. Ash, Rugby. Electric Arc Furnaces.** (1 *Fig.*) March 19, 1918.—This invention relates to electric arc furnaces. In carrying this invention into effect according to the arrangement illustrated, in which it is shown in connection with a three-phase furnace of the "Heroult" type, in which no neutral is provided, an artificial neutral, which may take the form of a reactance 1 connected across the secondary of the power transformer 2 supplying current to the furnace 3, is provided. Across each leg of the reactance, corresponding to each phase in the transformer secondary, a contact-making voltmeter 4 is connected. A contact-making ammeter 5 is also connected in the usual way in each phase of the secondary. The moving contacts connected to the plungers of both the ammeters and the voltmeters are connected across a direct-current supply. Connected between one of the stationary contacts 6 of the voltmeter and the corresponding stationary contact 7 of the ammeter in each phase is the coil 8 of a contactor controlling the rotation in one direction of the electrode-operating



motor, while between the other stationary contacts 9 and 10 respectively is connected the coil 11 of a contactor controlling the rotation of the motor in the other direction. With this arrangement, when any variation of current occurs in any of the phases without a rise or fall in the potential, the motor circuit will not be completed, and therefore the position of the electrode will not be altered. Where a neutral is provided, taken from the bottom of the furnace for example, the reactance may be omitted and the contact-making voltmeters may be connected between the neutral and each leg of the secondary of the power transformer. (*Accepted August* 20, 1919.)

**130,687. C. C. Gow, Westminster, London. Electric Furnaces.** (4 *Figs.*) March 14, 1918.—During the operation of electric furnaces, more particularly those employed in the manufacture of steel, gases are evolved which, finding an exit in the annular space between the carbon electrode and the water-cooling boxes, raise the temperature of the electrode to a red heat for a distance of some inches above the cooling box. Under these conditions the carbon is attacked by the surrounding air and any air which finds its way into the furnace through the various joints, which are never absolutely airtight, and mixes with the upward current of furnace gases. Due to this cause there results a considerable useless and wasteful consumption of carbon, and the diameter of the carbon is irregularly reduced, which again increases the means of escape for the gases. According to the present invention, a sleeve surrounding the carbons is mounted in such a manner that there is only a very narrow annular channel between the sleeve and the carbon for the passage of the gases, while at the same time there is no resistance offered to the forward or backward movement of the carbons. A is a sleeve surrounding an electrode B, and surrounded by a ring C adapted to slide laterally on a cooling box D. The lower



end of the sleeve A is rounded, as shown, so as to enable it to roll on the convex inner surface of the ring C. The rocking and sliding movements of the sleeve will allow it to adapt itself easily to any change in the position of the water cooler D, due to deformation of the roof or to any want of accurate axial alignment of the carbon, although the annular channel E between the carbon and the sleeve may be very narrow. The resistance offered by this comparatively long and restricted path prevents the flow of any large volume of gas and cools the heated gases by the transference of heat through the material of the sleeve. The upper end of the sleeve forms a support for magnetic segments G, which are magnetised and drawn inwards across the circular lines of force due to the current traversing the electrode. The inner edges of the segments are, preferably, rounded off as shown. A cover H prevents the access of dust, which might impede the free movement of the segments, and a downwards projecting rim of the cover resting on the flat top F of the sleeve provides an enclosed space in which the segments G are free to move laterally. The segments may, if it is found advisable, be laminated in order to prevent eddy currents. (*Accepted August* 20, 1919.)

### GUNS AND EXPLOSIVES.

**128,962. J. H. Hammond, Junior, Gloucester, Mass., U.S.A., Launching and Steering Torpedoes.** (15 *Figs.*) December 9, 1915.—Consists in directing launching tubes from a distance, for example by a distant sighting device, by means of step-by-step transmitters and receivers working in synchronism. In the form shown in Figs. 1 and 2, a sighting device 1 is geared to a step-by-step transmitter 6 connected by leads 7 to a step-by-step receiver 8, which is geared to an azimuth ring 18 made with two half-circular contacts 22, 23, forming a hunting switch with a contact arm 21 depending from a torpedo tube 10. This switch controls a shunt motor 16 through a relay comprising two solenoids 32, 33, with a battery 30 in circuit with the azimuth ring and contact arm, and a switch 34 actuated by the solenoids for doubly closing and opening the armature circuit of the motor 16, which is geared to the trainable base 11 of the torpedo tube and causes it to follow the direction of the sighting device 1. Where several torpedo tubes are used, they may be made to converge or diverge relatively to each other, for example, by means similar to the means for causing convergence and divergence several of torpedoes described in Specification No. 17300/15. Or convergence or divergence may be superimposed on the direction given to the tube by adjustments of the gyroscopic steering gears of the torpedoes by the means described in the aforesaid specification. Instead of the electric hunting switches described in the aforesaid specification, hunting valves may be used for adjusting the gyroscopic steering gears. Various other devices described in the aforesaid specification, for example, sight correctors, may also be used in conjunction with the present invention. An electric step-by-step transmitting and receiving system suitable for the purpose of the invention is shown in Fig. 3. The torpedo tube is carried by a spindle 196 which is geared to a pair of countershafts 198, 200, and can be moved step by step in one direction or the other by means of ratchet pawls 202, 204, connected to rocking armatures of electromagnets Rc, Rcc. The distant sighting device by means of which the torpedo tube is controlled is mounted on the spindle of an arm 180 moving over an azimuth ring comprising insulated semicircular segments 181, 184. The azimuth ring is geared to a pair of countershafts 188, 190, and can be moved step by step in one direction or the other by means of ratchet pawls 192, 194, connected to rocking armatures of electromagnets Tc, Tcc. Any movement of the sighting device causing the arm 180 to touch one of the contacts 181 or 184 of the azimuth ring completes the circuit of one of the transmitting electromagnets Tc, Tcc, say Tc. The armature of this electromagnet is thereupon rocked and

*Fig. 1.*

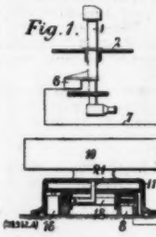
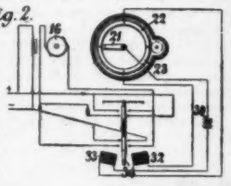


*Fig. 2.*



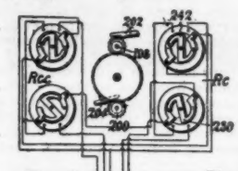


*Fig. 3.*

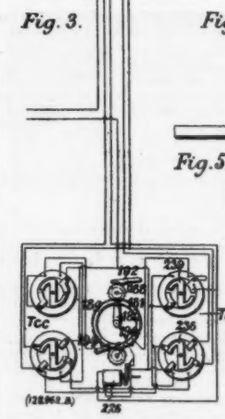


*Fig. 4.*

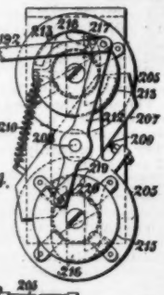


*Fig. 5.*



rotates the azimuth ring one step. At the same time, a bridge contact 239 is rotated by the armature to complete the circuit of the electromagnet independently of the azimuth ring, in order to ensure the completion of the sequence of operations thus initiated. Another bridge contact 236 is also rotated by the armature and closes the circuit of the receiving electromagnet Rc, the armature of which rocks and rotates the torpedo tube one step corresponding to the rotary step of the azimuth ring at the transmitting station. The armature of the receiving electromagnet Rc, at the same time rotates two bridge contacts 242, 230. The bridge contact 242 closes the circuit of a relay, 225, at the transmitting station to put the azimuth ring temporarily out of action to prevent the arm 180 from initiating a fresh step while the sequence of operations required for completing the first step is proceeding. The other bridge contact 230 actuated by the armature of the receiving electromagnet Rc serves to break the circuit of the transmitting electromagnet Tc when the armature of the receiving electromagnet has performed the above mentioned functions. The armature of the transmitting electromagnet is then rocked back by a spring to its normal position. This cuts the circuit of the receiving electromagnet, which is also returned by a spring to its normal position. This in turn cuts the circuit of the relay 225 and restores the operative control of the azimuth ring over the transmitting electromagnets. If the arm 180 is still, or is again brought, on a contact of the azimuth ring, a fresh step is made in the rotational positions of the azimuth rings and torpedo tubes, thus ensuring that the torpedo tube shall follow synchronously the movements of the sighting device. An electromagnet suitable for the above described operations is shown in Figs. 4 and 5. It comprises a pair of coils 205, and an armature 207, which is mounted on a spindle 208 and is normally held against a screw stop 209 by a spring 210. The pole-pieces are cut away as shown in dotted lines in Fig. 4 to permit the rocking movement of the armature. The armature is connected to the ratchet pawl 192 by means of an arm 212 on its spindle. The bridge contacts 239, 236, actuated by the armature are carried by two discs 213, 215, which have slots 218, 219, engaged by pins 217, 230, on the arm 212. (*Sealed.*)